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ABSTRACT

This report deals with a preliminary investigation of the problems associated with the determination of the total life costs of buildings, including cyclical renewal. It discusses also the benefits to be derived from this information, using life costs of a selected building as an example. The first portion of the publication considers problems in calculating life costs, a study of life costs of a particular university building, and the life cost-building system relationship. The second part of the document gives the scope and definition of cyclical renewal and then examines the renovations, alterations, equipment, and furniture components of cyclical renewal. Included in the appendixes are a proposal for study of life costs, a computer program for life cost projections, an index for maintenance and operating costs, the relationship between capital investment and discounted annual savings, data used, a glossary of terms, and a bibliography. (Author/DN)

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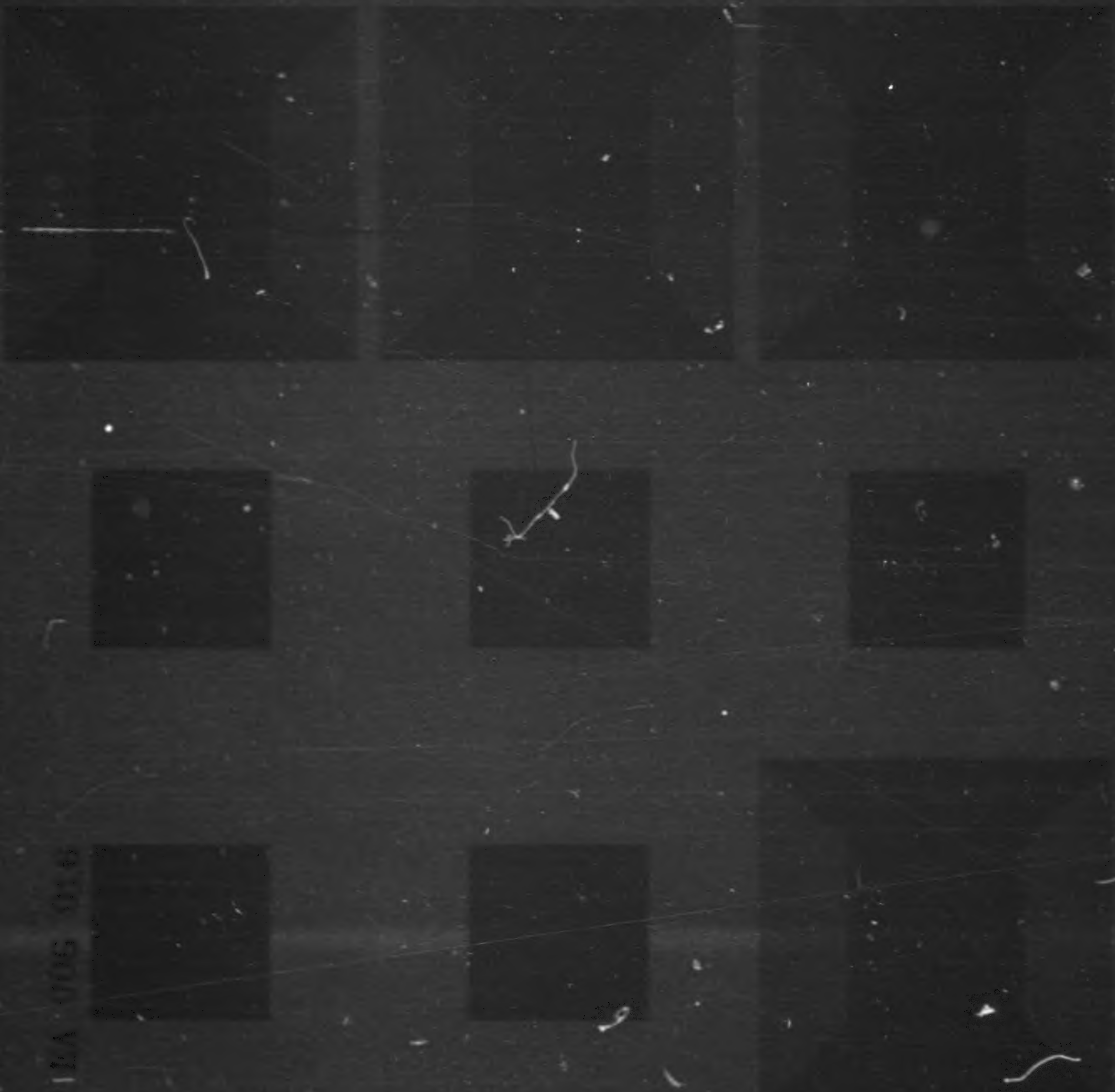
Building Blocks

Background Studies on the Development
of a Capital Formula for Ontario

VOLUME 5

Report of the Task Force
BUILDING LIFE COSTS



EA 006 016

Report
on
Building Life Costs

A preliminary investigation of the problems associated with the determination of the total life costs of buildings, including cyclical renewal, and of the benefits to be derived from this information, using the life costs of a selected building as an example.

Prepared
by
THE TASK FORCE - BUILDING LIFE COSTS

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November 1973

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The Task Force wishes to acknowledge the help of all those who provided information and assistance to it. Special thanks are due to:-

- the University of Windsor for permission to use their Faculty of Law Building in the study and their co-operation with the Task Force in establishing the life costs of this building.

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P R E F A C E

This report on building life costs is the fifth of the series *Building Blocks: Background Studies on the Development of a Capital Formula for Ontario* produced by task forces of the Council of Ontario Universities' Committee on Capital Financing. This latest report, the costs of which were shared equally by the Council of Ontario Universities and the Ministry of Colleges and Universities, arose from the study of initial building costs, published as Volume IV of this series. Among the conclusions reported in Volume IV was that not enough was known about life costs of university buildings and their relation to initial costs. As a result, the Committee on Capital Financing was asked to proceed with phase II of the building cost study, a pilot investigation of life costs (including cyclic renewal) in relation to initial costs.

The Council of Ontario Universities received the report of the Task Force-Life Costs on March 1, 1974. In considering the report, Council had at hand commentaries prepared by the Ontario Association of Physical Plant and Planning Administrators and the Committee on Capital Financing. The Council requested that a specific proposal for an extension of the study be developed.

The Council commends the Committee on Capital Financing and its task forces for continuing high-quality contributions to the literature on capital financing and physical resource allocation. This volume, prepared by the Task Force-Life Costs under the chairmanship of Mr. Henry Graupner, is a timely, unique, and worthwhile contribution to the literature and to the state of the art.

March 22, 1974

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SUMMARY AND MAJOR RECOMMENDATIONS

The work of the Task Force on Life Costs was sponsored by the Council of Ontario Universities and the Capital Support Branch of the Ministry of Colleges and Universities. The Task Force has carried out a preliminary investigation of the problems associated with the determination of the total life cost of buildings, including cyclical renewal, and of the benefits to be derived from this information. The life costs of the Faculty of Law Building at the University of Windsor, were evaluated using the method of analysis suggested by the Task Force, as an example of the problems and the type of results to be obtained.

The work of the Task Force, which has extended over approximately twelve months, has resulted in an approach to the problem of calculating life costs, which has not been found elsewhere, based on a search of the fairly lengthy list of references and discussions with a number of persons in other institutions who are also involved in the same general area. The Task Force feels that a solid basis has been established for carrying out more extensive studies on life costs of actual buildings, but that the conclusions and recommendations contained in this report are of a tentative nature in many aspects. The main reason for this is that insufficient time and man hours were available to establish the size of data base necessary in order to be able to draw firm conclusions.

During a recent year, about $50 million was spent by the Ontario universities on operations and maintenance of their physical plant. The Task Force is convinced that if the work of this pilot study is expanded into a major study of life costs, universities would obtain considerable assistance in being able to reduce these annual operating and maintenance costs, or at least slow down their increase in the face of continuing inflation of labour and material costs.

This report lists a number of recommendations, of which the major ones can be outlined in this summary as follows:

(1) The investigation of building life costs should be continued and completed, by a Task Force established for this purpose.

This report recommends in some detail, the variety of tasks to be undertaken by this future Task Force, but these can be summarized as being essentially the accumulation of a greater data base and the establishment of a system of making the results of the analysis of these data available and of assistance to the universities.

(2) Consideration should be given to increasing the current 1% allowance for cyclical renewal, and to making changes in the present policy regarding capital support for cyclical renewals, relating to:

- the inventory base to be used in the formula

- equipment and furniture

> The Task Force has assessed the costs of cyclical renewal work and has presented a range of data on which an interim increased allowance could be based. However, a greater statistical base must be established to confirm the level of adequate allowances for each of the components.

A complete list of recommendations is found in Section 8.2 of part 1 of this report and Section 7.2 of part 2.

With reference to the Windsor Law Building, the application of the analysis methods described in this study results in a life cost of approximately 6 to 7 million dollars in terms of the 1973 dollar, for the first 60 years of the building's life. This relates to a construction cost in 1968 dollars of $2.3 million. The actual figure for the life cost of this building would depend upon the assumptions made about a number of economic indicators which are used in the process of converting forecast future costs to their present value.

PART ONE
LIFE COSTS

1. INTRODUCTION

The work of the Task Force on Life Costs was carried out against a university financial background in which the amount of money available to universities was decreasing for both capital and operating purposes. Falling student enrolments or slower rates of growth, have resulted in the temporary cessation of provincial financial assistance for new building projects. This has increased the importance of obtaining maximum economic utilization from the present facilities. Also, an opportunity has been provided to assess what has been done in the past, in order to assist in formulating plans and policies for future university development.

At the same time, pressures on operating budgets arising from similar causes, made it imperative that individual universities seek ways and means of reducing, amongst many other items, the costs of operating and maintaining their physical plant. Some of these costs are primarily related to the design of the building, others are affected by the use of the building.

It was clear that a study of the life costs of a building, and their relationships to initial construction costs, would assist universities in understanding and in reducing physical plant owning costs. Also, a study of this type could establish the level at which lower operating costs justify increased capital costs.

In order to provide some idea of the importance of life cost considerations, it should be noted that during the year 1971-72 approximately 17 million net assignable square feet (approx. 30 million gross square feet) were in operation at the 14 Ontario universities. Using the capital formula of $55/NASF, this space would equal a replacement value of $935 million.

During the same year approximately $49 million was spent on operations and maintenance (excluding renovations and alterations but including physical plant administration, grounds maintenance and security).

If over a 60-year building life a 20% saving in these annual expenditures was achieved, the total saving over that period would amount to $588 million in constant dollar terms.* It is the conviction of the Task Force that there are opportunities to achieve very significant savings in the life costs of physical facilities throughout the Ontario university system.

It was within this context, that the Council of Ontario Universities agreed that Recommendation 5 of the Report of the Task Force on Building Costs, Building Blocks Volume 4, should be implemented. This recommendation dealt with the subject of building capital costs and reads:

> "The second phase of the study should be immediately implemented to include the study of life costs, including costs of maintenance, operations and change, and to analyze the validity of programmatic needs that result in higher design requirements and higher cost elements for buildings."

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* or $130M in present value terms, as defined in Section 5

The work was commenced in October 1972 by the members of the Task Force on Building Costs, which consisted of persons nominated by the Ontario Association of Physical Plant and Planning Administrators, and representatives of COU's Committee on Capital Financing. However, because the study of building life costs was of common concern to both the universities and the Ministry of Colleges and Universities, members of MCU staff were also appointed to the Task Force, which was then renamed the Task Force on Life Costs.

Shortly after its establishment, the Task Force agreed that exploratory work only, in the form of a pilot study, should be carried out before the details of a full scale study could be organized. Among the reasons for carrying out a pilot study before commencing a full scale study, were the following:

- the problems involved in acquiring the necessary data were not fully clear
- definitions of life costs had to be agreed and then tested for practicability against probable information availability
- little prior work in this area of study appeared to be available
- it was not possible to reliably assess the cost and duration of the full scale study
- limited time and funds were available

Following the decision to carry out a pilot study only, a more detailed statement of the objectives and proposed methodology was made and a proposal prepared. This was accepted both by the Ministry of Colleges and Universities, and by the Council of Ontario Universities on the recommendation of its Committee on Capital Financing. The Council and the Ministry agreed to share the costs of the study equally. These are mainly due to the use of consultants for much of the data accumulation and analysis work.

A copy of the complete study proposal is included in Appendix 1 to this report.

The work covered by this proposal is described in Part 1 of this report, which deals essentially with the total life costs of buildings, and, in particular, those of the Faculty of Law Building, University of Windsor.

Since costs of major renovations and alterations are part of building life costs, this study also looked into the subject of costs of cyclical renewal. The complete description of this phase of the study is included in Part 2 of this report which has been prepared in such a way that it is self-contained and can be used as a complete statement of the Task Force's work on cyclical renewal. A separate list of conclusions and recommendations on cyclical renewal has been prepared.

A number of appendices at the end of this report, contain technical, statistical and other background data. In addition, two sets of all source data and survey responses have been accumulated and filed at COU and MCU, for reference purposes.

2. OUTLINE OF WORK OF TASK FORCE

A summary of the various tasks carried out by or on behalf of the Task Force, will provide an introduction to the sections of the report that follow. These deal in detail with the various studies and analyses from which the conclusions and recommendations are derived.

There have been 19 meetings of the Task Force. During these meetings, the Task Force normally reviewed progress to date, discussed and agreed on methods of analysis, outlined work to be carried out by members of the Task Force and consultants and advisers, and controlled progress of the work. The work consisted of the following tasks:

(a) Discussion of the initial need for a preliminary investigation, rather than a complete and exhaustive study of life costs

(b) Preparation of a proposal covering a preliminary investigation

(c) A search of the bibliography and contact with others doing work in the same general area

(d) Assessment of costs of major renovations to buildings, equipment and furniture

(e) Investigation of actual costs of alterations of Ontario university buildings in the past few years

(f) Assessment of a recommended interim cyclical renewal allowance

(g) A review of operating and maintenance cost data for the Law Building at the University of Windsor and the extraction and re-classification of the required data

(h) An attempt to establish the correlation between elements of operating and maintenance costs and elements of capital costs

(i) A survey of universities to establish the availability of annual operating and maintenance cost data for individual buildings

(j) An analysis of the factors affecting heating, ventilation and air conditioning systems and costs in a building

(k) Investigation of the use and benefit of a computer program for energy consumption and costs

(l) A comparison of energy consumption between an existing HVAC system and a possible alternative that was available to the designer of a building

(m) Investigation of comments on the Meriwether computer program for energy consumption from those who have made use of or investigated it, e.g. Carleton University, University of Western Ontario, Department of Public Works Ottawa and Consumers Gas Limited.

(n) The development of a computer program for calculating total life costs from actual capital costs of construction, past operating and maintenance costs, and forecast future operating and maintenance costs.

(o) Obtained advice from an economist on methods of combining capital and operating costs occurring at different times and expressed in different dollar values.

(p) Calculation of the life cost for the Windsor Law Building, using the computer program, for several assumptions on inflation, building life, etc.

(q) Identification of the scope of future studies in this area

(r) Preparation of a full report on the pilot study and issue to the sponsoring organizations, COU and MCU, for their review, approval and decision on action to be taken.

During the course of the study, the Task Force made some minor changes to the activities outlined in the study proposal, for reasons related to the availability of time and money.

3. COMPARATIVE STUDIES

A continuing effort has been made to identify similar or related studies completed or in process. The majority of agencies and groups likely to be undertaking such studies in Canada, were contacted. The survey revealed that very little research on life costs has been done or is in process.

Every agency contacted expressed great interest in the subject and the technique as an effective decision making tool, especially for governmental and institutional builders, who will be continuing owner-occupiers. The Federal Department of Public Works (DPW) has recently established a research and development group who intend among other things, to investigate life-cycle costing problems and applications. The Federal Department of Health and Welfare (DHW) is investigating with interest work being done in the U.S.A. and U.K. and intend arranging a symposium on the subject shortly. DPW is also using the Meriwether* computer programs for life cost analysis of heating, ventilating and air conditioning (HVAC).

The majority of those contacted seemed to have been deterred from lauching any studies of their own by two factors:

(a) the daunting prospect of identifying operating and maintenance costs for individual buildings in a meaningful way, for use in life cost studies

(b) the lack of funds for undertaking the necessary research and, in some cases, an inability to identify where to start.

In many cases, maintenance records are being improved and computerized, to permit the retrieval of data in a variety of forms. At the Federal level, pressure is being brought to bear by Treasury Board on all property owning departments, to improve their record keeping.

The Department of Public Works (British Columbia) is also moving towards a major costs-in-use study, beginning with the organization of their data base.

Apart from specific articles and literature on maintenance and operating problems, virtually no Canadian literature on the subject of life costs could be found.

Elsewhere, in the U.S.A. and U.K., considerable work has been done, as the bibliography (Appendix 2) testifies. In the U.S.A., the technique of life cost analysis (or life cycle costing as it is more frequently called there), was pioneered by the Department of Defence and the armed services. The government construction agencies are adapting it to their own use, particularly Health, Education and Welfare (HEW) and the General Services Administration (GSA). Interest also appears to be shown by several other groups and it is not unknown for building owners to commission architects and cost consultants to specifically undertake life cycle cost studies during design. The GSA has recently called tenders for three major social security administration payment centres, with proponents bids including renewable five year maintenance agreements(35)* In the U.K., costs-in-use studies have been widespread for many years and the work of Dr. P.A. Stone is especially recognized in this field(1). The sources and references obtained from both these countries, have been extremely valuable in formulating our approach and adapting ideas and experience to the specific milieu of the Ontario universities.

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* See Section 7.6 for description

Special mention should be made of the work being done at the University of Michigan by a graduate student of the Architectural Research Laboratory. An analysis of the operating and maintenance costs for 70 different buildings over a long period of time has been made, together with the development of computer programs for identification and quantification of factors influencing costs and their correlation to building design and capital costs. The paper is expected to be completed later this year and should be available for public use. The work has been reviewed by the Task Force.

For those wishing to develop a better understanding on the subject of life costs, the following texts from the bibliography are recommended:

(1) Building Design Evaluation - Costs in Use, P.A. Stone, E. & F. Spon Ltd., London

Stone is regarded as the major authority in the U.K. on this subject. He was Chief Economist at the Building Research Station at the time his book was written. The book is a good introduction to the subject, discusses many of the issues involved in the financial calculations and includes a number of examples of applications. Significantly, Stone excludes occupancy costs from his definition of costs-in-use.

(27) Costs-in-Use - A Guide to Data & Techniques, Dept. of the Environment, Property Services Agency, Directorate of Quantity Surveying Development, London

This report reviews the life cost conclusions contained in several other reports on school buildings, housing and government office buildings. The report analyzes the effects of building age on operating and maintenance costs. It also discusses the use of the data by design teams, the sensitivity of the various factors included and some examples of use.

(31) Study of Health Facilities Construction Costs - Summary Report from study undertaken by Westinghouse Health Systems, sponsored by the General Accounting Office, Washington, D.C.

This is an actual case study of life cost applications to the analysis of a number of alternatives for health facilities such as the dietary system, material handling system, laundry, etc. What is particularly interesting in this study is that it takes into account, occupancy costs in addition to capital, operating and maintenance costs.

* These numbers refer to the listing in the Bibliography.

4. DEFINITION OF LIFE COSTS

4.1 How Life Costs are Used

The technique of life cost analysis is essentially a comparative tool for studying design alternatives and analyzing their cost implications over the life of the building. There are two basic situations in which the technique can be applied, in the context of more economic university physical plant acquisition and operation:

(a) Total building life cost studies

These may involve two objectives:

- collection of life costs on a building by building basis in order to accumulate a body of data for the analysis of factors which affect total life costs (cf. University of Michigan study referred to in Section 3 - Comparative Studies)
- comparative building life cost studies prepared during conceptual design stages, to compare alternative solutions (e.g. to build new or renovate, to build permanently or temporarily, etc.)

(b) Building system life cost studies

Again, these may involve two objectives:

- collection of historical data for purposes of analysis and correlation
- comparative analysis of design alternatives

The latter may involve complex elements (such as HVAC systems) or simpler subjects (such as carpet versus vinyl asbestos tile). Some may have a bearing on and interface with many building sub-systems, some may be quite self-contained.

Outside the context of this report, a further use for life cost analysis is in the area of systems and equipment required to support the activities of the occupants, e.g. food service, garbage handling, library systems. These analyses would include consideration of wage costs, in addition to those capital and other operating costs considered in this report. It may also be necessary to attempt to quantify intangibles such as quality of service.

The Task Force recognized that occupancy costs can represent a high proportion of total annual costs.

The Task Force felt that, since university buildings were usually designed in accordance with, and to provide facilities for, a pre-determined set of user requirements, design decisions would not affect occupancy costs in a measurable way. Where a study does require that such costs be considered, it was felt to be most unlikely that adequate records presently existed for individual buildings.

For these reasons, occupancy costs are excluded both from the definition and the analysis of building life costs, for the purposes of this study.

As a final comment, it is expected that in the future, with the expected greater emphasis on program budgeting, such costs might have to be identified and incorporated into life cost studies. Extensive research would then be required to develop a methodology for measuring such costs and for establishing the impact of building design factors on annual occupancy costs.

4.2 Broad Definition

In view of the general lack of comparative research, no standard definitions of life costs exist. Even the subject itself is called by different names: life cycle costs (USA), costs-in-use (UK). As the application of life cost studies is usually a matter of comparisons between alternative courses of action and of design, it is important that a consistent definition of the elements to be admitted into any life cost study be established. As it is unlikely that one definition can be acceptable to all potential users of life cost analysis, the definitions that follow take into account the special characteristics of universities, in particular those related to physical plant construction and operation.

For this purpose, the life cost of a building is made up of two basic components:

(a) the initial capital costs

(b) the annual operation and maintenance costs (including major renovations, alterations and replacements), over the assumed life of the building.

The following paragraphs analyze what is included in these two basic components.

4.3 Capital Costs

The capital costs included in these life cost calculations are as follows:

(a) Actual construction cost of the building, including all change orders

(b) Architectural and engineering fees

(c) Furniture and equipment supplied to the building

These costs correspond to those reported by universities for each provincially assisted project on the MCU FINAL COST REPORT, CSP SUPPLEMENT D. It should be noted that this cost report does not supply the level of detail required in life cost analysis. It is usually necessary to refer also to an elemental cost breakdown of the type found in the MCU PROJECT COST ELEMENT ANALYSIS, CSP SUPPLEMENT B, or a quantity surveyor's estimate form, and to purchase orders or other lists of equipment and furniture.

Another source of capital cost breakdown is the contractor's final certificate of payment. This lists costs by trade and would require some analysis to convert it to an elemental breakdown.

In addition, change orders should be included, wherever possible, to make the capital cost data complete. These probably require allocation to the various elements, but in many cases, pro-rata distribution would be accurate enough.

The following items have been excluded from capital costs, for the reasons stated:-

(a) Land costs

Where comparisons of life costs relate to different designs on one site, land costs would be common to all options and hence, can be omitted. Where different sites are involved, land cost differentials should be taken into consideration. For potential, or newly purchased, sites, evaluating this differential might present little difficulty.

If required in any particular cost study, the valuation of a building site enclosed by other campus land, might present problems. The Task Force did not investigate this matter.

(b) Site works and landscaping

These should be considered separate from building life cost studies, unless they directly and significantly affect the life costs.

4.4 Annual Costs, including Major Renovations, Alterations and Replacements

OAPPPA published in 1972 a classification of physical plant functions, now in general use within the Ontario university system. It was considered appropriate that this be used in defining the operating and maintenance cost content of life costs, because:

- no better classification system could be found
- cost data in the universities would be available in this format and could be used in this study without re-classification

Costs of all physical plant functions are allocated to the following items in the OAPPPA classification system:-

(1) Physical plant administration
(2) Building maintenance
(3) Custodial services
(4) Utilities
(5) Landscape and grounds maintenance
(6) Safety, security and traffic
(7) Other
(8) Renovations, alterations and major repairs

However, the definition of life costs adopted by the Task Force includes only the following cost categories in the OAPPPA system:-

(2) Building maintenance

(3) Custodial services

(4) Utilities

(8) Renovations, alterations and major repairs

Full descriptions of these items may be found in Appendix 5, pages 6-8.

It should be noted that item 8, renovations, alterations and major repairs, refers here to work funded from operating budgets, since the OAPPPA classification system covers only operating budgets. In this study, this item has been treated in two ways, as follows:

- for determining total life costs, an adequate allowance has been included, based on the sum of costs funded from operating and capital budgets
- in those sections dealing with the size of an allowance for cyclical renewal*, only capital budget work has been included.

It has been argued that costs of alterations to buildings incurred due to changes in their use, should be excluded from building life cost studies. These changes are difficult to predict, while the alterations themselves, may have far reaching implications concerning operating and maintenance costs. However, these costs were considered to be an appropriate element of life costs for university buildings. There is a high probability of alterations occurring in an environment of many differing uses, organizational units and constant change.

The Task Force notes that life cost study techniques could be used to assist in making the decision whether to alter an existing building or build new space.

4.5 Costs Excluded from Definition

Reasons for excluding four of the OAPPPA classifications are as follows:

(1) Physical plant administration costs

It was decided to omit these costs because it was felt that the addition of a single building to an existing campus tended to have only marginal effect on the level of administration costs. There seemed little point in pro-rating the cost on a gross or net assignable square foot basis, as only subsequent variations in building size rather than design, would have any effect upon this cost allocation.

* as defined by the Task Force (see Part 2 of this report)

(5) Landscape and grounds maintenance

This item was excluded because it is not directly related to the building design.

(6) Safety, security and traffic

This was excluded for reasons similar to those applying for administration costs.

(7) Other

This is a category in the OAPPPA for miscellaneous items which will not fit into any other category. All costs of interest in this life cost study can be classified in the cost categories included in the definition.

5. PROBLEMS IN CALCULATING LIFE COSTS

It was pointed out in Section 3, how little material of assistance to the study was found in a search of the books and articles listed in the Bibliography, although isolated topics are well covered, such as:-

- the relationship between HVAC system selection and utilities costs
- building obsolescence
- maintenance costs
- energy (utilities) conservation

However, none of the available references can be used as a guide to the evaluation of the total life cost for a building. The work of the Task Force broke new ground, essentially unaided by previous studies.

In so doing, the Task Force met a number of problems and issues, which had to be resolved, in some cases only tentatively, before the step by step procedure for the life cost evaluation could be completed. This section deals with these matters and indicates where assumptions were made for the purposes of this preliminary investigation, and which issues remain to be resolved following further study.

The items to be discussed in this section can be grouped under seven general headings, which are:-

1. Data availability
2. Life of a building and its components
3. Conversion of past cost data to present value
4. Forecast future costs
5. Conversion to current-equivalent costs (present value)
6. Problems in defining a procedure for measuring current-equivalent costs
7. Life costs computer program

5.1 Data Availability

(a) Capital costs

Data on actual capital costs of buildings generally were found to be readily available, either from the university itself or from MCU. As an alternative to these two sources, they could be determined, at some cost, by estimating the building costs on the basis of tender documents, i.e. drawings and specifications. Further comments on these sources are contained in Section 4.3 of the report.

(b) Operating and maintenance costs

All university physical plant departments maintain annual cost records covering the operation and upkeep of the campus plant, for a number of purposes. These records show the cost for the total campus, of the various categories of costs outlined in section 4.4. Universities also have records in one form or another, of costs of work covered by cyclical renewal. However, for more than half the universities, these data were not in a form required by the Task Force for calculation of building life costs, i.e. they were not available for individual buildings.

Most of these universities have stated that it would be very difficult and time consuming, if possible at all, to establish costs for individual buildings, by analysis of the existing records. This conclusion is clear from the responses to the various surveys made at the universities in this matter. Appendix 5 to this report contains details of one of these surveys, which dealt with the availability of annual operating and maintenance cost data for individual buildings.

Even where annual costs records for an individual building were maintained, there was a cost involved in extracting, re-classifying, etc. the required data. These costs are assessed in Section 6.3, where this process for the Windsor Law Building is described.

The Task Force concluded that a comprehensive study of the life costs of a large number of buildings, could not be undertaken until this lack of data was remedied.

5.2 Life of a Building and its Components

Life cost studies require a knowledge of the length of the useful life of a particular building, and the durability or life expectancy of major components of the building. Little useful information apparently exists in this area. These two related problems were handled as follows:

(a) Building life

Prediction of the useful life of a specific building can be hazardous and subject to misinterpretation. For commercial buildings, the problem could easily be resolved by setting the life over the period of amortization allowed for taxation or financing purposes. For non-commercial buildings, including university buildings, it could be argued that they can be useful for as long as one is prepared to make them. Some of the buildings at Oxford and Cambridge Universities are good examples of this. A high level of maintenance would have been required, however, to permit such a long life.

It is possible that certain buildings in the future may become so expensive to operate and maintain that it would make sense to demolish them and build new space. This condition may arise if operating and maintenance costs escalate at an increasingly rapid rate while at the same time improved building methods provide better, more feasible and more economic alternative accommodation. The Task Force did not pursue this idea.

For the purposes of this study, a cost horizon of 60 years was used for most purposes. It should not be inferred that the Task Force is recommending that buildings be demolished after 60 years. In effect, the study neglects costs beyond 60 years since they are difficult to predict, and have little effect on forecast life costs on a present value basis.

In any case, a computer program for evaluating the present value of forecast life costs was developed for this study. This can carry out the appropriate calculations for any assumed building life between 30 and 140 years.

(b) Durability of building components

The Task Force found very little information available on actual or probable durabilities for common construction items. The durability of some items, such as roof finishes, can usually be established with reasonable accuracy but other building components such as curtain walls become highly judgemental. It was obvious that there existed a need for a feedback system on every building not only to provide data for life cost studies but also to enable cash flow profiles for building maintenance to be planned well in advance.

A related issue is the identification of reasons for replacements or major repairs and their correlation to the original specifications and design criteria. Where failures are due to reasons other than normal wear and tear*, then the recycling of this knowledge into future design and planning processes would be invaluable and hopefully avoid repetition of mistakes. Furthermore, the life of a component will often depend on the quality of maintenance supplied.

In reference 1, Stone points out that theoretically, durability should be determined on the basis of observed probabilities of failure. He states that there is a tendency to overestimate the frequency of replacement, due to the fact that the only information that is available, is for components that have failed while none is available obviously for those that have not. In some ways, this problem of durability is one of the key issues, particularly where concern is mainly with alternative design solutions and their life costs.

The Task Force overcame this lack of relevant data by using the judgement and experience of groups of physical plant staff (engineers, maintenance supervisors) to provide the Task Force with expected replacement cycle periods for the various elements of typical buildings on their campus. The results of such a process are discussed in part two of this report. The process was also used for the Windsor Law Building, as noted in Section 6 of part one of the report.

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* such as, for example, the use of materials under circumstances for which they were not designed, resulting in early and significant failure, but outside any guarantee coverage

5.3 Conversion of Past Cost Data to Present Value

This study required the conversion of historical cost data to present values and the elimination of the effect of inflation. This applied not only to capital costs, but also to operating and maintenance costs.

In view of the limitations of published building cost indices, the recommendations contained in Building Blocks Volume 4 regarding the use of these indices for capital costs, were accepted. On page 69 of that report, it is noted that a more realistic estimate of the escalation of construction costs was 50% of the published data. In the analysis of life costs for the Windsor Law Building, the Task Force made use of the actual escalation applicable to that building, as estimated in Building Blocks Volume 4.

The Task Force is aware of the plans of Statistics Canada, Ottawa, for the production of a reliable index. However, it will be several years before this index is available and it will not be possible to use that index to update capital costs for buildings tendered prior to the present time.

For operating and maintenance costs, the Task Force developed an index for its own use, which is fully described in Appendix 8 of this report. More detailed analysis is required to completely validate the tentative results of the suggested methodology.

5.4 Forecast Future Costs

It is normal to forecast future costs of maintenance and operation for a building on the basis of known costs in the past, modified by any known changes considered likely to occur in the future. The difficulties of obtaining specific known annual costs is covered in section 5.1. Assuming they are available, it would then be possible to forecast annual costs in the future, in terms of the same dollar used in the past cost data.

There are two problems with this approach, which relate to the future rate of usage of the required resources, i.e. the effect of aging, and the future change in unit costs of such resources.

(a) Aging

There appeared to be some evidence to support the view that building operating and maintenance costs increase with age of the building. Presumably, much depends on the quality of maintenance being provided, on preventative maintenance programs and on prompt replacement or repair of worn out or obsolescent components and materials. A further moderating influence on the effect of age, tends to be exerted by the fact that the majority of university buildings during their lives, undergo changes in use resulting in extensive renovations and alterations. At this time, it is customary to upgrade sub-systems and components, thus reverting large sections of the building to a new condition.

Research carried out in England (27) appears to prove that age is the greatest single factor on the level of maintenance costs. Figure 1 on the following page, reproduced from this publication, gives some indication of the magnitude established (all values are brought to a June 1971 level). The chart shows increase ranging from about 1% to a high of 20% per year.

Research carried out at the University of Windsor found a definite correlation between building age and power consumption, which had a tendency to increase at an average rate of approximately 6% p.a* Whether this is due to a decreasing efficiency of the building system, or to increasing user demands, or a combination of both, was not established.

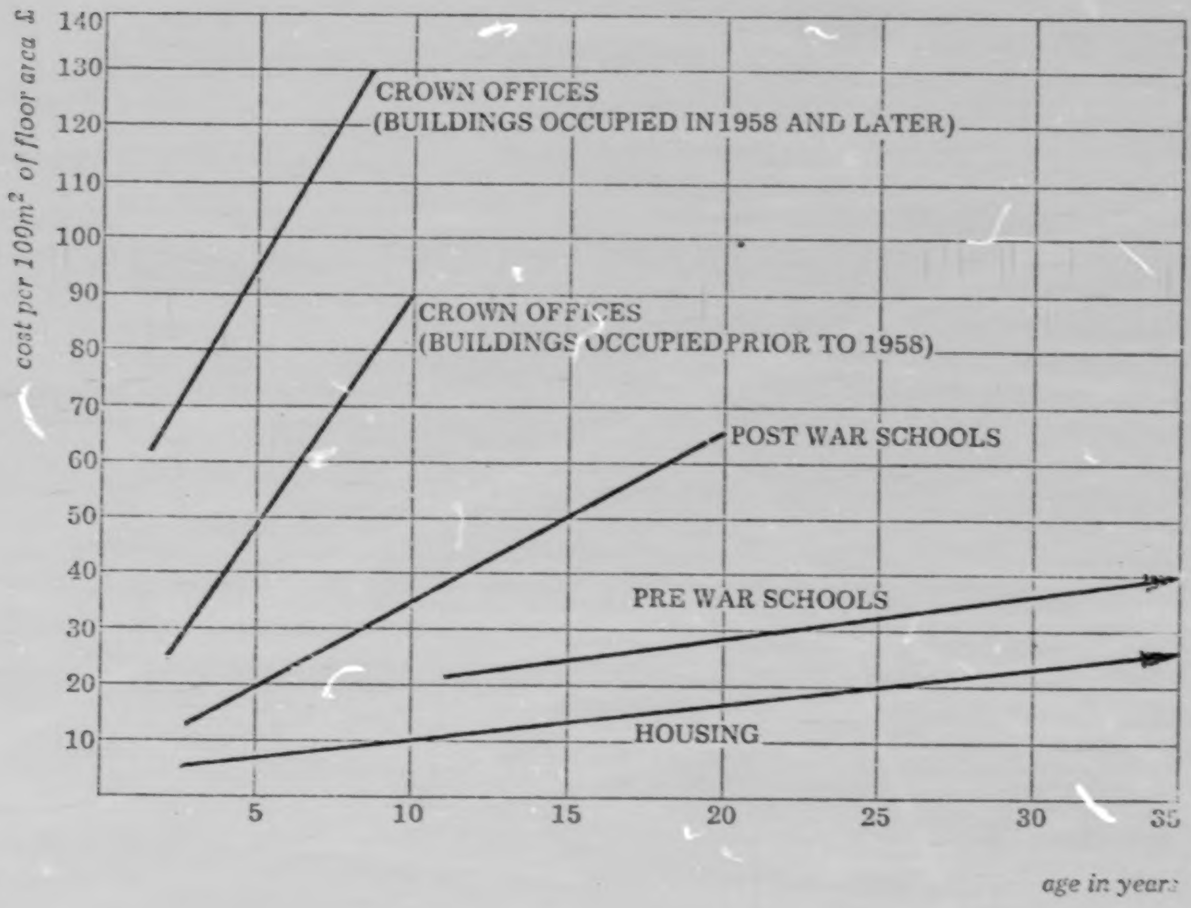
An analysis was made of the operating and maintenance costs at Carleton University, for the period 1965 to 1971, in an attempt to relate these to the increasing maturity of the buildings in use. The study confirmed that the unit cost of maintenance ($ per NASF), increased on a trend basis by an average of 2.2% p.a. during the period, after bringing all costs to a 1969 base, using the prototype maintenance index described in Appendix 8. Over this period, the building

* Reference 25 in the Bibliography. See also page 75 of Reference 38, which corroborates the Windsor experience with similar findings at Stanford University.

Figure 1

COMPARISON OF MAINTENANCE COSTS BY BUILDING USE AND CONSTRUCTION

Excluding Redecorations and Minor New Works



Source: "Costs-in-Use - A guide to Data & Techniques" (27) inventory at Carleton was growing by an average of 23% p.a. and the average age of the space was also increasing from 4.0 years to 6.4 years or an average of 10% per year*. There could be many reasons for the average 2.2% p.a. increase in costs and it would therefore be unwise to assume that increasing building maturity automatically brings higher maintenance costs. Further studies should properly be done over a longer period of time.

A similar study was undertaken for the period 1966 to 1972 for the University of Windsor*. Here it was found that unit costs of maintenance per NASF were increasing at the rate of 3.2% p.a. after discounting inflation. During this period, the average age of the space in the inventory remained virtually static, due to building activity which increased the inventory by an average of 15% p.a.

(b) Cost inflation

In life cost studies extending into the future, a key question is the extent, if any, to which the rate of cost increase of each category of costs will vary from the general rate of price inflation. While physical plant budgeting and similar activities may require knowledge of expected total annual rates of increase of such costs, in life cost studies, it is important to predict the extent to which prices of construction materials, utilities, and services may change relative to general price changes. Techniques for converting future costs to their equivalent present values, automatically make allowances for the expected rate of general inflation. In the past, the major deviant cost category has been utilities, since the prices of fuel and electricity have not risen as fast as prices in general. Over the next 15 to 18 years, by contrast, it has been estimated that prices of fuels are likely to double, relative to general price levels.

Specific assumptions made about expected rates of relative price changes, in calculating the Windsor Law Building life costs, are described in Section 6.

5.5 Conversion to Current Equivalent Costs

5.5.1 Conceptual Problems

It is not always obvious how capital and operating costs for one choice can be combined, in order to be able to make meaningful comparisons between their combined value and that of another choice. There are three principal reasons for this:

(a) The capital and operating costs described in Section 4 are typically defined to be of different dimension. That is, capital costs are defined as total dollars spent once on constructing a building while operating costs are defined as dollars spent per year. In addition, the two types of costs occur at different times.

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* Source data on file at COU and MCU

The problem arising from the different dimensions and timing of capital and operating costs is basically a conceptual one. It is also related to the more general one of evaluating social investments. In addition to this conceptual problem, there are two difficulties of measurement arising from the effect of cost and price inflation.

(b) Capital and operating costs are not measured in terms of comparable costs. Capital costs are normally based on construction costs as of the date the contract is tendered. Operating costs are normally measured from actual operating costs at a series of later dates. Inflation in each type of cost must be measured in order to convert each cost figure into estimates measured in terms of costs of some standard year that makes them comparable.

(c) Operating, repair, and renovation costs will also be incurred in future years in which they are obviously not known now with certainty. It is consequently necessary to specify how future costs will relate to current costs of each type. In particular, it is necessary to specify whether specific costs are likely to grow faster than other categories of cost.

The following describes a method of calculation by which these problems can be overcome.

5.5.2 Combining Capital and Operating Costs

The question of how to compare these two categories of cost may be clarified by putting the question in planning decision terms: how much should be spent in additional capital cost in order to reduce operating costs by one dollar per year? Putting the life cost definition question in this context emphasizes the fact that the primary use of life costs is in the comparison of choices.

The answer to this question clearly depends on the further question, for how many years will the operating costs be incurred?

The appropriate way to combine capital and operating costs is:

(1) to determine how many dollars it would be worth investing in additional capital costs if by so doing operating costs could be eliminated, and

(2) to add this amount to the capital cost known to be incurred

From the university's viewpoint, it is necessary to determine what criteria should determine planning choices. The viewpoint taken in this report, is that such criteria (at least for publicly-supported universities) will reflect the criteria generally applicable to government investment decisions.

From the government's viewpoint, it is worth postponing some costs. If the government incurs an expenditure in one year in order to avoid a larger expenditure in a subsequent year, it may choose to finance the earlier expenditure by borrowing (e.g. by selling government bonds). In this case, it is economical to make the earlier expenditure only if the sum of this expenditure plus the compounded interest which the government must pay to borrow this amount is less than the later expenditure which is thereby avoided. Alternatively, if the government chooses to finance the earlier expenditure from taxes, it foregoes the opportunity of reducing outstanding government debt (along with subsequent interest payments) if it uses the tax revenue to finance the earlier expenditure. In this case, the earlier expenditure is economical only if the later expenditure thereby avoided is greater than the sum of the first expenditure and the compounded interest which the government could have saved by using its funds to reduce outstanding debt.

The compounded interest on an earlier expenditure reflects the fact that, from a social viewpoint, the resources allocated to construction of capital facilities have alternative uses. If resources allocated to construction can be reduced by postponing some costs, the resources thus freed can be used for other purposes in the interim until they are required to meet the postponed costs. As a result, resources available earlier are more valuable, both to private individuals and businesses and to governments. The bond market serves to provide a measure of the greater social value of earlier resources by providing a market in which the varying private and government demands for funds at different market prices (interest rates) are balanced against the amounts of funds which investors are willing to supply at such prices.

It is convenient to use the long term interest rate on government debt to measure the market value of the earlier availability of resources. The relative value of resources available now (Vo) compared to that of resources available n years later (Vn) may be expressed in terms of this interest rate (r) using well known mathematics of compound interest*. The basic point is of course, simply that Vo is greater than Vn because of the usefulness of resources available for alternative uses even only for very brief periods such as the n years over which costs may be postponed. The use of the interest rate (rather than the ratio Vo/Vn or other measure) to reflect this is merely an indication of general usage.

What this greater value of earlier resources implies is that for the government (and society generally) it is worth spending a dollar now to avoid an expenditure n years later only if the value of the later expenditure is greater than the relative value of resources available in year n. Expressing this in terms of the interest rate, the cost avoiding current expenditure should be undertaken only if the later cost is greater than $(1+r)^n$ times the current expenditure, where r is the real rate of interest.

* Specifically, the relationship is expressed by the equation

$$Vo/Vn = (1+r)^n$$

Alternatively, the current cost which is equivalent to an expenditure of E dollars n years later, is the later expenditure divided by $(1+r)^n$. This current-equivalent amount is often called the "present value" of the future expenditure.

To combine capital and operating costs, it is therefore necessary to determine the current-equivalent of the operating costs in each future year and to add the sum of these current-equivalents to the construction cost of the building*.

5.6 Problems in Defining a Procedure for Measuring Current-Equivalent Cost

Having stated a definition of total life costs that enables capital and operating costs to be combined, it is necessary to note some of the conceptual problems that need to be dealt with in applying this definition. It is important to note that these problems are inherent and always present in life cost studies, whether they are dealt with explicitly or implicitly.

5.6.1 Choosing the Correct Interest Rate

Because the market rate of interest depends in part on investors' anticipations regarding future price inflation, it is necessary to be sure that such inflation anticipations are reflected in the costs estimated for future years in order that the interest rate and future costs are consistent. Alternatively, the rate of anticipated inflation may be subtracted from the market rate in order to derive the "real" rate of interest. In the latter case, future costs should be estimated without incorporating the effects of general price inflation.

The market rate of interest is often called the "nominal" or "quoted" rate of interest, to distinguish it from the two factors (anticipated price inflation and the "real" social rate of interest) which are subsumed in the rate quoted in financial markets.

The "real" rate of interest is more stable than the market rate of interest, because of fluctuations in investors' anticipations about future price inflation. Most economists would estimate the "real" rate of interest to be between 3.5 and 4%. As a general rule, it is wise to calculate using a number of interest rates in order to be able to see to what extent the calculations are sensitive to the choice of interest rate.

In many studies, all operating costs over the anticipated life of the building are simply added together and combined with capital costs. What such a procedure implicitly assumes is that the "real" rate of interest is zero, which is not a realistic assumption.

* This can be written in specific terms as follows. If the operating costs in each year are denoted by Ot (t denoting the year) and C denotes the construction cost, then the total lifetime costs of the building are

$$C + \frac{O_1}{1+r} + \frac{O_2}{(1+r)^2} + \frac{O_3}{(1+r)^3} + \cdot \cdot \cdot \cdot \cdot + \frac{O_k}{(1+r)^k}$$

Where k is the life of the building. This expression provides a definition of life costs.

Moreover, such a procedure implies that it would be profitable for society to invest more in capital costs than would in fact be economical*.

5.6.2 How Long will the Building Last?

This question was discussed in Section 5.2 above.

5.6.3 How Comparable are Historical Cost Figures?

This question was discussed in Section 5.3 above.

5.6.4 By how much will Costs Rise?

See Section 5.4 above.

5.7 Life Costs Computer Program

To reflect all of the issues discussed above and to allow for easy recalculation of total life costs under varying assumptions, a computer program was developed to handle life cost calculations. The program deck is available for Ontario university use at COU.

Input for the computer program is described in detail in Appendix 6, which includes as an example, a computer printout of the input required to produce life cost calculations for the specific building discussed in Section 6.

The program provides for an input of detailed specification of construction costs, annual operating costs, and costs of cyclic renewals and renovations. In addition, detailed cost adjustment, inflation, and efficiency change factors are specified. The program, given this input, then calculates expenditures on a common basis for a specified number of years (incorporating the effect of all specified adjustments). From the resultant vector of estimated expenditures in each year, the program calculates the present value of these expenditures over varying planning horizons for different discount rates. Both "real" and nominal or market interest rates are shown for given assumptions regarding the anticipated rate of general price inflation.

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* A numerical example will indicate how much of a bias is implied by (incorrectly) assuming a zero rate of interest. For a building with an anticipated life of 60 years, the use of a zero rate of interest implicitly presumes that the value of one dollar saved in the sixtieth year of the building's life is 9.15 times as great as that which is implied by a real interest rate of 3.75%.

6. LIFE COSTS FOR FACULTY OF LAW BUILDING

6.1 Introduction

In order to test the methodology developed in this study, it was decided to select an actual building and to assess the total life costs for it. In addition to testing the methodology, this procedure had the advantage of:

- establishing broad orders of magnitude between various life cost components for an actual building

- establishing the validity of continuing actual life cost studies for buildings in use

- appraising the time and effort expended in developing and obtaining cost data for such a study

6.2 Selection of Building

In order to simplify the process, it was decided to use one of the buildings which was analyzed in Building Blocks Volume 4. After consideration of the six university buildings in this study, the Faculty of Law Building at the University of Windsor was selected as being the most suitable for this purpose.

Selection of an appropriate building was made on the basis of the following criteria:

- that the building had been in operation for several years

- that it was a well-defined separated structure

- that it was not too specialized

- that there had been no major change

- that the university had data available that could be analyzed for the selected building

6.3 Cost Data

6.3.1 Capital Costs

The capital cost analysis previously prepared for the Building Blocks Volume 4 study was converted from 1971 Toronto costs to the actual costs incurred at the time of construction, including all change orders.

It was decided to list capital costs in five main categories as follows:-

(1) Foundations and structure
(2) Envelope
(3) Interiors
(4) M & E systems
(5) Furniture and equipment

All overhead costs and design fees were allocated on a pro-rata basis to the value of each of these five categories.

6.3.2 Operating and Maintenance Costs

Actual operating and maintenance costs incurred since the opening of the building (for a period of three years from September 1969) were obtained from the files of the University of Windsor. While these costs were fortunately available separately for this specific building, it was necessary to reclassify them into the OAPPPA classification system. The costs were also broken down into finer detail, in order that they could be correlated with capital cost elements. The work of producing the O & M data absorbed University of Windsor personnel in approximately 140 hours of time (4 man-weeks). It should be noted that steam, water and power are not metered at this building and the costs are therefore pro-rated from campus totals.

6.3.3 Cyclical Renewal

This has been estimated as follows:

(a) Renovations - a careful analysis was made of the materials and components specified for this building* Opinions were sought from suppliers, sub-trades and the industry on anticipated replacement cycles, which were then reviewed and confirmed by the University of Windsor staff. The cycles were taken over 60 years and it is possible that, had a longer cycle been taken, then additional items would have been admitted into the calculations. The estimates are therefore biased downwards, as for example, items requiring replacement at 100 year cycles would not be included.

(b) Alterations - the mean cost of alterations established in the cyclical renewal study (part 2 of this report) was used, since the building is so new that no alterations have yet been carried out. The combined allowance for capital and operating fund alterations was used.

(c) Equipment and furniture replacement - the costs of this were assessed on the expected life cycles of the various items of equipment and furniture purchased for this building* The life cycles and resulting costs agree closely with the analysis for the cyclical renewal allowances described in part 2 of this report.

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* See Appendix 4 for details

6.4 Comprehensive Building Data

In order to permit comparisons between total life costs for a number of buildings, it will be necessary to record certain key statistics and information for each building. Table 1 on the following page suggests a selection of these parameters, which it was believed, have the greatest influence on building life costs. They are relatively easy to measure and establish. Comments on some of the items are as follows:

- areas are measured in accordance with MCU rules
- maximum population is the sum total of all student and work stations in the building
- the hours of annual usage means the hours the building is open to general usage during the calendar year
- number of rooms includes all assignable spaces, together with equipment rooms, toilets, major assembly spaces, etc.
- categories of functional areas are in accordance with MCU data
- exterior wall area includes basement wall area
- percentage wall and roof area glazed represents percentage glazed above grade

TABLE 1

Basic Data for Life Cost Analysis

Building: Faculty of Law Building
University of Windsor

Location: Windsor, Ontario

Use: Education and training in both classroom and courtroom for faculty of law students, together with extensive autonomous library and case research facilities: faculty secretarial/office facilities

A. CAPITAL COSTS (Oct. 1968 dollars)	Net Cost	Pro-rata Overheads, Fees, etc.	Unescalated Undiscounted Life Cost
(1) Foundations & Structure	$ 515,910	$ 58,800	$ 574,710
(2) Envelope	293,290	33,470	326,760
(3) Interiors	485,350	55,370	540,720
(4) M & E Systems	587,210	66,960	654,170
Construction Costs	$1,881,760	$ 214,600	$ 2,096,360
(5) Furniture & Equipment	237,510	nil	237,510
Totals	$2,119,270	$ 214,600	$ 2,333,870

B. OPERATING & MAINTENANCE COSTS	Actual Costs to 3/31/73*	Projection to 3/31/2020	
(1) Administration	$ excl.	excl.	excl.
(2) Building maintenance	21,330	405,270	426,600
(3) Custodial services	155,610	2,956,590	3,112,200
(4) Utilities	119,570	2,271,830	2,391,400
(5) Landscape & grounds	excl.	excl.	excl.
(6) Safety, security & traffic	excl.	excl.	excl.
(7) Other	excl.	excl.	excl.
(8) Renovs., alts. and major repairs			
(a) Renovations component	nil	1,515,180	1,515,180
(b) Alterations component	nil	1,043,600	1,043,600
(c) Code component	excl.	excl.	excl.
(d) Equipment component	nil	152,180	152,180
(e) Furniture component	nil	542,740	542,740
Totals	$ 296,510	$ 8,887,390	$ 9,183,900
TOTAL UNESCALATED, UNDISCOUNTED LIFE COST			$11,517,770

C. BUILDING DATA

Date of tender:	October 1968
Date of occupation:	Sept. 1970
Volume:	1,213,843 CF
Gross Floor Area:	85,140 SF
Net assignable floor area:	52,311 SF
Number of basement levels:	1
No. of floors above grade:	2
Maximum population:	650
Est. annual usage (hours):	4,074 Hrs
No. of rooms:	100
Type of maintenance operation: in house except outside contracts	
Quality of maintenance:	High
Projected life for analysis	60 Yrs
*Actual costs cover	36 Mo

Functional area breakdown:	
classrooms	8,631 SF
special purpose	6,173 SF
offices	8,736 SF
library	26,208 SF
general	2,563 SF
Total net floor area:	52,311 SF
Roof area	32,905 SF
Grade area	29,700 SF
Exterior wall area:	46,480 SF
Total envelope area:	109,085 SF
12.1% wall & roof glazed	9,566 SF

6.5 Life Cost Calculation Assumptions

This section describes the calculations for the life costs of the Windsor Law Building, for the first 60 years of its life. The computer program described in Appendix 6 was used with the building data in Table 1 on page 1.27 providing the required inputs. The program also required the use of a number of factors and assumptions, which are essentially those required to deal with the problems and issues raised in Section 5. These factors and assumptions can be summarized as follows:

(a) Capital cost escalation - a factor of 18/31 of the published Southam Composite Construction Index (Ontario Series), was used to inflate the actual construction costs at time of tender to present value. Southam indices (1961 base 100) are 143.3 for October 1968 and 232.9 for August 1973. (See Section 5.3). The inflation of equipment and furniture costs has been treated in the same way.

(b) Operating and maintenance cost escalation - in order to inflate actual costs of utilities, maintenance and custodial services from the years 1970-1973 to August 1973 values, the index derived in Appendix 8 was used. The relevant data are as follows:

	% increase of costs/unit of input over previous year			
	1970	1971	1972	1973
Maintenance	8.6%	8.1%	6.2%	8.1%
Custodial services	8.3	8.4	5.1	10.7
Utilities	5.6	4.1	3.6	3.0

For the purposes of forecasting future costs of operation and maintenance, a rate of cost increase equivalent to general price inflation has been assumed for all elements of these costs except utilities. This rate also applies to costs of major repairs, renovations, alterations, and other components of cyclical renewal.

For utilities, it has been forecast that the price of these would double over the next 15 to 18 years, relative to general price levels.* Thereafter, increases have been assumed to be equal to general price inflation. The effect of this assumption on life costs has been demonstrated by calculating the life cost both with and without this relative price change.

(c) Effect of age - as discussed in Section 5.4, there remains considerable work to establish the full effect of age on the various cost elements. However, to show the change in life costs of such an aging effect, the 6% annual growth of power consumption has been included in one of the life cost calculations. This rate of growth is expressed as a percentage of the base year, and is equivalent to an annual compounded rate of 2.2%.

(d) Cyclical renewal expenditures - although this report recommends an annual allowance for these, the life cost calculation assumes these expenditures are grouped, and occur at certain intervals of say, 10 or 15 years. The actual replacement cycles used for each cost element and sub-element, are listed in Appendix 6. The life cost computer program does allow for a percentage of each of these elemental costs to be incurred equally distributed on an annual basis, if a given life cost calculation requires this.

(e) Building life - the computer program permits calculation of a number of assumed years of life, or cost horizons. The printouts for this particular set of calculations highlight the 60 year period.

(f) Interest rates - as discussed in Section 5.6, a real interest rate of 3.5% and 4.0% has been highlighted in the printouts. These correspond to a market rate (or nominal or quoted rate) of 7.0% and 7.5% respectively and infer an expected average annual general price increase of 3.5% from now to the cost horizon.

Table 1 also includes forecasts over the first 60 years of the building's life, made on a straight line basis, assuming costs will not increase, in terms of current dollars, as the building gets older. These forecasts do not discount future costs and assume no inflation.

6.6 Results of Life Cost Calculations

The estimated total life costs in 1973 dollars for the Windsor Law Building were calculated by computer program for three differing sets of conditions:-

1. Assuming no post-1973 inflation in any relative prices and no post-1973 change in efficiency of use of inputs.

2. As above, except that the relative price of utilities is assumed to double by 1990.

3. As in case 2, with efficiency of use of electrical services assumed to decrease by a non-compounded 6% per year (assumed to be equivalent to a 2.2% compounded deterioration in efficiency).

The results for these three cases are presented in tables 2 to 4 on the following pages. In these tables, results are highlighted for a 60 year cost horizon and real interest rates of 3.5% and 4.0%. These results are, it is felt, the ones most often relevant for planning purposes.

These results can be compared to the figure shown in Table 1 for a life cost which neglects differences between 1969 and 1973 dollars, and which projects future annual costs in terms of undiscounted 1973 dollars.

Table 2

Case 1 - No cost inflation

PRESENT VALUE OF TOTAL BUILDING COSTS OVER LIFE
FOR DIFFERENT ASSUMED LIVES AND DISCOUNT RATES
(MILLIONS OF DOLLARS)

DISCOUNT RATE		-------------- EXPECTED BUILDING LIFE (YEARS) --------------						
REAL	NOMINAL	30	40	50	60	75	100	125
0.0	0.035	7.29	9.10	11.06	13.15	15.46	20.45	25.00
0.005	0.040	6.88	8.40	9.96	11.54	13.19	16.41	19.00
0.010	0.045	6.52	7.78	9.03	10.22	11.41	13.49	14.98
0.015	0.050	6.19	7.25	8.25	9.15	10.00	11.36	12.21
0.020	0.055	5.89	6.78	7.58	8.27	8.87	9.76	10.25
0.025	0.060	5.62	6.37	7.01	7.53	7.97	8.55	8.84
0.030	0.065	5.38	6.01	6.52	6.92	7.24	7.62	7.78
0.035	0.070	5.16	5.69	6.10	6.41	6.63	6.88	6.98
0.040	0.075	4.96	5.41	5.74	5.97	6.13	6.30	6.36
0.045	0.080	4.78	5.15	5.42	5.60	5.72	5.83	5.86
0.050	0.085	4.61	4.93	5.15	5.28	5.37	5.44	5.46
0.055	0.090	4.46	4.73	4.90	5.01	5.07	5.12	5.13
0.060	0.095	4.32	4.55	4.69	4.77	4.82	4.85	4.86
0.065	0.100	4.19	4.39	4.50	4.56	4.60	4.62	4.62
0.070	0.105	4.07	4.24	4.33	4.38	4.40	4.42	4.42
0.075	0.110	3.97	4.11	4.18	4.22	4.24	4.25	4.25
0.080	0.115	3.87	3.99	4.05	4.08	4.09	4.10	4.10
0.085	0.120	3.78	3.88	3.93	3.95	3.96	3.96	3.96
0.090	0.125	3.69	3.78	3.82	3.84	3.84	3.85	3.85
0.095	0.130	3.61	3.69	3.72	3.73	3.74	3.74	3.74
0.100	0.135	3.54	3.60	3.63	3.64	3.64	3.64	3.64

Table 3

Case 2 - Doubling of fuel costs by 1990

PRESENT VALUE OF TOTAL BUILDING COSTS OVER LIFE
FOR DIFFERENT ASSUMED LIVES AND DISCOUNT RATES
(MILLIONS OF DOLLARS)

DISCOUNT RATE		EXPECTED BUILDING LIFE (YEARS)						
REAL	NOMINAL	30	40	50	60	75	100	125
0.0	0.035	7.94	10.18	12.57	15.08	18.05	24.11	29.73
0.005	0.040	7.46	9.34	11.25	13.15	15.27	19.19	22.39
0.010	0.045	7.04	8.61	10.14	11.58	13.09	15.64	17.47
0.015	0.050	6.66	7.98	9.20	10.30	11.38	13.03	14.09
0.020	0.055	6.32	7.43	8.40	9.24	10.02	11.10	11.71
0.025	0.060	6.01	6.94	7.73	8.36	8.92	9.63	9.98
0.030	0.065	5.73	6.51	7.14	7.63	8.03	8.50	8.70
0.035	0.070	5.47	6.14	6.65	7.01	7.31	7.61	7.73
0.040	0.075	5.25	5.81	6.21	6.50	6.71	6.91	6.98
0.045	0.080	5.04	5.51	5.84	6.06	6.21	6.35	6.39
0.050	0.085	4.85	5.25	5.51	5.68	5.79	5.88	5.91
0.055	0.090	4.68	5.01	5.23	5.36	5.44	5.50	5.51
0.060	0.095	4.52	4.80	4.98	5.08	5.14	5.18	5.19
0.065	0.100	4.37	4.62	4.76	4.83	4.88	4.90	4.91
0.070	0.105	4.24	4.45	4.56	4.62	4.65	4.67	4.67
0.075	0.110	4.12	4.29	4.39	4.43	4.46	4.47	4.47
0.080	0.115	4.01	4.16	4.23	4.27	4.28	4.29	4.29
0.085	0.120	3.90	4.03	4.09	4.12	4.13	4.14	4.14
0.090	0.125	3.81	3.92	3.97	3.99	4.00	4.00	4.00
0.095	0.130	3.72	3.81	3.85	3.87	3.88	3.88	3.88
0.100	0.135	3.64	3.72	3.75	3.76	3.77	3.77	3.77

Table 4

Case 3 - Doubling of fuel costs by 1990 and additive 6% increase in consumption of electrical services

PRESENT VALUE OF TOTAL BUILDING COSTS OVER LIFE
FOR DIFFERENT ASSUMED LIVES AND DISCOUNT RATES
(MILLIONS OF DOLLARS)

DISCOUNT RATE		EXPECTED BUILDING LIFE (YEARS)						
REAL	NOMINAL	35	40	50	60	75	100	125
0.0	0.035	8.63	11.64	15.16	19.25	25.59	41.14	63.70
0.005	0.040	8.08	10.61	13.42	16.52	21.05	31.08	43.93
0.010	0.045	7.60	9.72	11.97	14.32	17.56	24.05	31.40
0.015	0.050	7.16	8.94	10.74	12.53	14.86	19.08	23.29
0.020	0.055	6.77	8.27	9.71	11.07	12.75	15.49	17.92
0.025	0.060	6.41	7.68	8.84	9.88	11.08	12.88	14.28
0.030	0.065	6.1[illegible]	7.16	8.09	8.89	9.76	10.94	11.75
0.035	0.070	5.81	6.71	7.46	8.07	8.69	9.47	9.95
0.040	0.075	5.55	6.31	6.91	7.38	7.83	8.35	8.62
0.045	0.080	5.31	5.95	6.44	6.80	7.13	7.47	7.63
0.050	0.085	5.1[illegible]	5.64	6.03	6.31	6.55	6.78	6.87
0.055	0.090	4.90	5.36	5.68	5.89	6.07	6.22	6.28
0.060	0.095	4.72	5.11	5.37	5.54	5.66	5.76	5.80
0.065	0.100	4.56	4.89	5.16	5.23	5.32	5.39	5.41
0.070	0.105	4.41	4.69	4.86	4.96	5.03	5.08	5.09
0.075	0.110	4.28	4.52	4.65	4.73	4.78	4.81	4.82
0.080	0.115	4.15	4.36	4.47	4.53	4.56	4.58	4.59
0.085	0.120	4.04	4.21	4.30	4.35	4.37	4.39	4.39
0.090	0.125	3.93	4.08	4.15	4.19	4.21	4.22	4.22
0.095	0.130	3.83	3.96	4.02	4.05	4.06	4.07	4.07
0.100	0.135	3.74	3.85	3.90	3.92	3.93	3.94	3.94

Results can be summarized as follows:-

Life Costs for first 60 years life of Windsor Law Building

Table 1 - actual dollars, no discounted projections	$ 11.52M
Table 2 - no future relative price changes, no effect of age on consumption (7½% discount)	5.97M
Table 3 - as for Table 2, except utilities price doubled by 1990 relative to general inflation (7½% discount)	6.50M
Table 4 - as for Table 3, but with annual increased consumption of power (7½% discount)	7.38M

Table 2 provides a useful example of the importance of discounting and of the interaction of assumptions regarding the interest rate and assumptions about the cost horizon. Using a correct real rate of interest (between 3.5% and 4.0%) the total life cost of the building is calculated to be between $6.0 million and $6.4 million, assuming a 60-year cost horizon. These figures are about half the sum of undiscounted costs over this period. The life cost for the building using a real rate of interest of between 3.5% and 4.0% is also relatively insensitive to the actual period used; doubling the cost horizon to 125 years increases total life costs by less than 10%. (By contrast, total undiscounted costs are almost doubled).

Tables 3 and 4 illustrate the sensitivity of the results to alternative assumptions regarding cost inflation. Table 3 shows that the effect of the generally anticipated doubling in fuel prices is likely to have a greater effect on total life costs of the Law School building than a doubling of its life without this fuel price increase.

6.7 Relationship between Capital and Operating Costs

The proportion of the total life cost formed by the capital cost and the operating cost components, depends upon the assumptions made regarding escalation, inflation, discount rate and the other factors previously discussed. The following tabulation shows the relationship between these two components for the four cases summarized above.

	Assumptions	Total Life Cost	Relative Percentages Capital	Relative Percentages O & M, incl. C.R.
1. A	Unescalated, undiscounted (Table 1)	$ 11.52M	20%	80%
1. B	Undiscounted, capital cost escalated to 1973*	11.99M	23	77
2.	7½% discount, no future relative price changes (Table 2)	5.97M	47	53
3.	7½% discount, utilities price doubled by 1990 (Table 3)	6.50M	43	57
4.	7½% discount, utilities price and consumption increase (Table 4)	7.38M	38	62

* 1968 capital cost of $2.33M is equivalent to $2.80M in 1973 dollars

The above tabulation clearly indicates the importance of the present value method of calculating life costs. In the undiscounted cases, the relationship of capital to operating is in the order of 1:4. However, this changes almost to a 1:1 ratio, when future annual costs are converted to their current equivalent value.

The bibliography contains two items in which reference is made to this relationship between the capital and operating costs. Stone (1), page 15, displays the following figures, which are based on the present value method of analysis, though the actual rate of discount is not stated.

Estimated Costs-in-Use for Typical Buildings

Type of Costs	Percentages Offices	High Flats	Houses	Factories	Hospitals	Schools
Initial	53	61	56	56	65	60
Maintenance	14	13	16	16	19	19
Fuel and attendance for heating and lighting	33	26	28	28	16	21

A direct comparison with the Windsor figures is not possible, because Stone's figures do not include alterations and replacement of furniture and equipment. However, if they did, the initial (i.e. capital) cost percentage would obviously be reduced, which would tend to make these figures similar to the Windsor percentage.

The Educational Facilities Laboratories booklet on energy conservation (33) on page 10 comments that:

"first cost constitutes roughly 8% of the total 40-year cost; O & M costs represent 12%; and teaching-administrative costs represent an overwhelming 80%".

It can be inferred that these figures are based on the present value method, since the booklet also explains this method of analysis. Thus, this reference indicates a ratio of 1:1½ between capital and O & M costs.

As a further check on the general validity of the relationship as derived for the Windsor building, an analogous present value life cost calculation was made for total capital and operating costs for the entire Windsor campus and the Ontario University system as a whole. Using a 7½% discount rate, over 60 years, on each of these two cases, produces the following results:

	Windsor Campus	Ontario System
Capital cost (based on $55 per NASF)	$ 46M	$ 935M
O & M costs, including allowance for cyclical renewal costs	3M p.a.	55M p.a.
Total life cost (7½%, 60 years)	86M	1,659M
Capital cost %	54%	56%
O & M costs (incl. C.R.) %	46%	44%

These figures also indicate that the relationship is in the order of 1:1.

6.8 Conclusions from total life cost analysis

Conclusion No. 1

Quantitative conclusions cannot be drawn from this analysis of a single building. The use of any one of the total life cost figures in Tables 1, 2, 3 or 4 as a "typical" building life cost should be avoided, unless clearly qualified by a statement on all of the assumptions, etc. that have been made. In the bibliography, the Task Force has found no dollar figure of building life cost that covers a comparable scope, that could have been used for comparison and validation purposes.

Thus, until a number of buildings have been subjected to the life cost analysis and a body of data is available, too much stress on the actual dollar figure should be avoided. What is of significance, are the differences between results arising out of different discount, etc. assumption. In this general area, more specific conclusions can be drawn as follows.

Conclusion No. 2

Overemphasis on operating and maintenance costs (at the expense of insufficient emphasis on capital costs) can result from the use of conventional and undiscounted evaluations of projected future costs. Comparability and validity can be achieved only if a common discount rate, assumed inflation rate, etc. are established for use in life cost analysis of Ontario university buildings.

Conclusion No. 3

The assumption relating to the length of the building life is relatively less significant than discount and inflation rates, in the evaluation of life costs.

Conclusion No. 4

The computer programme for evaluating life costs can be used in any building study, provided the definition of life costs remains the same as that used in the programme. The programme will always supply comparable answers, when used for different buildings, provided that input assumptions such as discount rates, are consistent.

The undiscounted, conventional life cost projection method will not provide comparable results unless the time spans with constant annual expenditure, are equal in the studies being compared. This is rarely the case and the Task Force concluded that the present value method was the only one which overcame this problem and which was able to take into consideration the conceptual problems described in Section 5.

7. LIFE COST - BUILDING SYSTEM RELATIONSHIP

7.1 General

It is generally agreed that the study of life costs is likely to return the greatest benefit in the comparative analysis of different building systems, both for new construction and buildings in operation. Studies may be conducted at a very simple level (e.g. wall tiling versus epoxy coating) or at a highly complex level in which several interrelated components or systems are involved (e.g. comparative lighting systems). For the purposes of the pilot study, it was decided to select a complex system from the Law Building, in order that techniques could be tested where a number of interrelationships were involved. The natural choice was the building HVAC system and this has been studied with the following objectives:

(a) to identify all factors (both building and operational) which influence system life cost

(b) to gain an understanding of the relative influence of each factor on system life cost

(c) to study some potential design options which might have been available to the designers to the building in relation to building design modifications, alternative HVAC systems and consideration of different operational conditions

The study was therefore undertaken to look at total life costs, rather than energy costs alone.

7.2 HVAC Life Costs

The capital cost of an HVAC system is influenced by two basic considerations: firstly, the output demanded of the system and, secondly, the type of system which is chosen to provide this output. Both decisions are influenced, to one degree or another, by a wide variety of factors. Similarly, the other component of life costs, being the cost of maintenance and the cost of energy consumption, is influenced in turn by the capacity and type of system designed and the conditions under which it is operated from an occupancy and climatic point of view.

Factors which influence the calculation of output or capacity of the system loads are as follows:

(a) Conduction heat gains or losses

  (1) Exterior wall and exposed overhangs

    - net area

    - "U" factor, which depends upon

      (i) type of wall
      (ii) insulation including air gap (if any)
      (iii) colour

    - (iv) finish
    - (v) construction material

- (2) Exterior glass (including rooflights)

  - net area

  - "U" factor, which depends upon

    - (i) type of glass
    - (ii) single or double glazed
    - (iii) colour
    - (iv) finish
    - (v) venetian blinds or shades

- (3) Floors

  - net area

  - "U" factor, which depends upon

    - (i) type of floors
    - (ii) insulation (if any)
    - (iii) construction material

- (4) Roof

  - net area

  - "U" factor, which depends upon

    - (i) type of roof
    - (ii) insulation
    - (iii) construction material
    - (iv) colour
    - (v) finish

(b) Excess solar gain

- (1) Latitude of the proposed building site

- (2) Heat gain factor which depends upon directional facing and colour of the different walls

- (3) Area of

  - (i) walls
  - (ii) glass
  - (iii) roof
  - (iv) skylights

(c) Design criteria

- desired inside conditions including relative humidity

- worst outside conditions to be assumed

(d) Internal loads

(1) People

- maximum number of people occupying the building at one time
- degree of activity (i.e. standing, sitting, walking, etc.)
- type of building (i.e. school, theatre, offices, etc.) and occupancy schedule
- special conditions (odours, fumes, etc.)

(2) Lighting

- type of fixtures

  (i) fluorescent
  (ii) incandescent

- number of fixtures and peak wattage

(3) Appliances and equipment

- kitchen equipment (cooking ranges, refrigerators)
- small and large electric motors
- gas equipment
- electric calculating machines
- other miscellaneous sources

(4) System

- gain or loss by the system components such as ducts, piping, fans, compressors, etc.

(5) Stairs, elevators, shafts, etc.

- location
- temperature and conditioning

(e) External loads

(1) Amount of fresh air (CFM)

- type of building (school, office, hospital, etc.)
- number of people

(2) Infiltration

- number of opening windows and doors
- wind velocity in the area
- difference in density (variation of temperature and humidity between outside and inside of the building)

(3) Adjoining buildings (if any)

- shading
- temperature
- conditioned or not

(4) Adjacent surfaces

- reflective quality (e.g. water, sand)

7.3 System Selection

Once the basic capacity of the HVAC system is calculated, the following factors then affect the selection of a system type to one degree or another:

- sources and type of energy
- control and zoning requirements
- space available for distribution (vertical and horizontal)
- location of main equipment rooms
- availability of roof for location of equipment
- terminal design limitations (dimensional and acoustic)
- comfort and noise levels
- visual restrictions
- number of floors and dispersal of space
- capital cost limits
- operating cost limits
- type of structure
- degree of interior flexibility required

7.4 Costs of Operation

During the operating life of the selected HVAC system, these factors affect the level of cost of operation:

- schedule of occupancy and operation
- capacity of systems
- flexibility and control of systems
- energy source
- system losses
- degree - day experience
- level of inside conditions established
- use of shading
- lighting levels
- length of heating and cooling seasons
- degree of recirculation
- system durability and reliability

7.5 Cost-Design Analysis

The factors listed in 7.2, 7.3 and 7.4 above, affecting HVAC system capacity, selection and operating cost, are widely understood by design engineers and generally appreciated by architects and building owners. However, because of the interaction of many of the factors and the introduction of a wide number of variables, the ability of anyone to comprehend fully the influence of any one factor is reduced to intuitive levels. Only through the use of computer-assisted analysis programs can the necessary calculations be made to enable a comprehensive economic analysis of design and operational options.

The ability to fully optimize these options is further complicated once costs are added to the equation, and complicated again once operating and maintenance considerations are taken into account, i.e. total life costs.

In order to appreciate some of these problems and to obtain some experience in attempting to resolve them, the Task Force searched for a powerful method of analysis, which would provide promise for the future and the immediate ability to assess the objectives of the HVAC system study.

7.6 Meriwether Programs

After reviewing a number of methods both manual and computer-assisted, it was decided to proceed with the so-called Meriwether programs of energy system simulation, developed by Ross R. Meriwether and Associates Inc., of Texas. This library of programs is available on a royalty basis through Consumers Computer Limited and rights have also been acquired for in-house use by the Department of Public Works of Ottawa. The programs have been used by the University of Western Ontario and satisfactory results obtained and it was therefore decided to experiment with their use for the Law Building study.

The programs provide an hour-by-hour calculation of the annual energy consumption of nine types of airside systems and mechanical plants. Each major step in a complete energy system analysis is handled by a different program, thereby permitting an evaluation of the results of one part before finalizing inputs and proceeding with the next part. The various programs permit the user to evaluate different airside system types, various control temperatures, air flow quantities, operating schedules, heat recovery or economizer cycles, various equipment types and accessory combinations, competing energy sources and alternate utility rates. A final program assesses total owning and operating costs.

It should be noted that the programs supplement existing load or output calculation techniques (whether manual or mechanized). Thus, the programs do not calculate heat gains or losses, for example, which must still be done by traditional methods. Nor do the programs take into account total cost optimization, but rather concentrate on optimization of the HVAC system alone. Informed users of the programs may, by reverse analysis, feed in these cost factors, but they are not automatic.

Further data on Meriwether programs is available directly from Consumers Computer Limited and outline summaries of the programs used in this study are on file at MCU and COU.

Whilst the Meriwether programs will return the greatest benefits in the analysis of new building designs, their application to an analysis of existing HVAC systems should not be underestimated. Such analysis permit the simulation of various changes to the existing building and system and an appraisal of their effects. The use of the programs is particularly appropriate where capital cost expenditures involving system changes, or building modifications (e.g. addition of window shading, addition of extra insulation, etc.) are contemplated.

7.7 Life Cost Analysis - HVAC System

Employing the Meriwether Energy System Analysis, the following studies were made:

(a) the actual system as installed

(b) an alternate system suitable for this building

(c) an alternative schedule of use

(d) an alternate architectural design option

7.7.1 The Actual System

A dual duct system has been used in the Law Building. This system may be described as a central plant which provides warm air alongside an adjacent system of cold air ducting. At each air conditioned area (zone), a mixing box merges the cold and warm air which is then discharged into the zone at the temperature required to control local conditions.

Capital cost of this system	$ 335,000	(1968 $)
Annual energy cost of the system (see Table 5 on page 1.44)	24,740	(1973 $)
Annual maintenance cost of the system	4,455	(1971 $)
Estimated cost of replacement and major repairs (over 60 years)	149,320	(1968 $)
Life cost based on 60 years (7.5% discount rate) - present value	830,230	

7.7.2 An Alternate System

In selecting an alternate HVAC system, three possibilities were examined:

(i) Terminal reheat

(ii) Terminal reheat - induction unit

(iii) Variable volume

Following discussions within the Task Force, it was decided to select for comparison with the existing installation, the terminal reheat system. This system may be described as a central plant which provides cold air all year round into a system of ductwork. At each conditioned area, a heating source is provided locally to temper the air to suit the area requirements. For this study, a hot water heating coil was considered.

Capital cost of the HVAC system	$ 309,000	(1968 $)
Capital cost savings (architectural)	nil	
Annual energy cost of the system (Table 5)	25,052	(1973 $)
Estimated annual maintenance cost of the system	4,680	(1971 $)
Estimated cost of replacement and major repairs (over 60 years)	139,730	(1968 $)
Life cost based on 60 years (7.5% discount) - present value	803,345	

Table 5

ANNUAL ENERGY CONSUMPTION (HVAC SYSTEM ONLY)

Systems:
- A. Double Duct, (min. dampers open at night)
- B. Double Duct, (dampers closed at night)
- C. Terminal Reheat, (min. dampers open at night)
- D. Double Duct, with modified glazing, (min. dampers open at night)

		System			
		A	B	C	D
Natural Gas					
1. Heating	MBTU	13,475,981	10,901,493	12,237,159	11,776,214
2. Humidification	MBTU	3,926,850	2,768,010	3,180,782	3,549,825
3. Domestic hot water system	MBTU	1,469,353	1,469,353	1,469,353	1,469,353
4. Total of 1, 2 and 3 plus 30%*	MBTU	24,533,839	19,680,513	21,953,482	21,834,010
5. Average gas unit rate	$/1000 CF	0.542	0.542	0.542	0.542
6. Total Amount	$	12,786	10,257	11,441	11,379
Electricity					
7. Cooling	Tons-Hrs.	373,882	560,303	548,223	344,311
8. Cooling**	KWH	388,837	582,715	570,152	358,083
9. Fans, motors, etc.	KWH	919,800	919,800	919,800	919,800
10. Total of 8 and 9 plus 5%***	KWH	1,374,069	1,577,640	1,564,450	1,341,778
11. Average unit rate	$/KWH	0.0087	0.0087	0.0087	0.0087
12. Total Amount	$	11,954	13,725	13,611	11,673
Total Annual Energy Cost (sum of 6 and 12)	$	24,740	23,982	25,052	23,052

* 30% added because of boilers, service tunnel and other mechanical equipment efficiency.

** 1 Ton-hr. = 1.04 KWH, from N. Fodor & Assoc. Ltd. Study on Central Plant of University of Windsor. This also allows for coefficient of performance, efficiencies, etc.

*** 2% added because of substation, transformer and transmission lines loss etc.; and 3% added for chilled water piping loss in service tunnel and mechanical room.

**** Direct comparisons between A and C cannot be made, because end results are not identical.

7.7.3 An Alternative Schedule of Use

It was suggested that the fresh air dampers of the existing system could be re-scheduled to close completely between midnight and 7:00 a.m. every day year round.

Some energy consumption savings are achieved on a yearly basis:

Dual duct system (Table 5)	$ 758 (1973 $)
Life cost based on 60 years (7.5% discount)	820,255

7.7.4 An Alternative Architectural Design Option

Skylights and glazing in the existing building were omitted or modified, in this theoretical alternative.

Capital cost of the HVAC system	$ 328,000 (1968 $)
Capital cost savings (architectural)	(89,500) (1968 $)
Annual energy cost of the system (Table 5)	23,052 (1973 $)
Annual maintenance cost of the system	4,455 (1971 $)
Estimated cost of replacement and major repairs (over 60 years)	149,320 (1968 $)
Life cost based on 60 years (7.5% discount rate)	684,855

7.7.5 Summary

In summary therefore, the calculated present values of system life costs for the four studies are as follows; in descending order of cost:-

		Present value	Ratio
A	the base building system (dual duct)	$ 830,230	100
B	closed fresh air dampers (dual duct)	820,255	99
C	alternate system (terminal reheat)	803,345	97
D	omission of skylights and windows	684,855	82

From these results, it should be evident that considerable benefits are likely to accrue from finer and more thorough analysis of building and HVAC design in terms of total life costs, optimizing the cost returns from a total integration of design and operational decisions.

7.8 Conclusions

General conclusions may be drawn from this preliminary HVAC analysis as follows:

(a) The returns to be gained from an optimization of HVAC system and building design will become more significant as energy costs escalate at the predicted rates. The use of a rational life cost methodology is essential to such a process of optimization.

(b) The Meriwether programs are a powerful tool now available to designers and physical plant administrators, for the hour-by-hour analysis of energy requirements. This in turn permits fine tuning of designs and operation, previously not possible by manual means. However, based on the limited experience so far obtained with this tool, the Task Force concluded that the programs are not easy to handle and require manipulation and use by qualified consulting engineers. Any agency or institution proposing to use them, should not underestimate the time required for familiarization and interpretation.

(c) The programs concentrate on the optimization of HVAC systems and do not provide for total building optimization, although this may be added manually.

(d) It is evident that a wide range of variables affect HVAC system life costs. These must be understood and identified and an order of magnitude estimate of their impact on total life costs established. Due to the complexity of the calculations, it is not possible at this time, without considerable expense, to ascertain the life cost effects of more than one variable at a time. The Meriwether programs for example, are particularly rigid in this respect and require separate runs for each variation, although possible boundaries may be set for each variable and interpolation assumed in certain cases.

(e) While the limited scope of this pilot analysis is insufficient to draw any significant conclusions about this building, it can be seen that a 3% savings in life costs appears to be possible by changing the schedule of operation of the dampers in the system, as explained in section 7.7.3*

(f) Larger life cost savings, in the order of 17.5%, appear possible with an alternative architectural design option, but this statement should be viewed in the light of the next conclusion.

(g) The Task Force felt unjustified in drawing any technical conclusions from this quantitative, computerized analysis of the actual or possible alternative HVAC system, because:

- lack of time to review the computer results thoroughly which is felt to be necessary because of problems inherent with the use of computers, e.g. key punch errors, input data requirements not understood, data transposed, etc.

* This neglects the additional savings from the effects of free cooling when outside temperatures are below about 65°F.

- the programs do not consider architectural and physical factors (including aesthetics and convenience), which may require to be changed with the use of the possible alternatives, for example, headroom dimensions, duct shaft sizes. The study did not progress in the time and with the resources available, to a consideration of these factors.

8. CONCLUSIONS AND RECOMMENDATIONS

The members of the Task Force have found the study very interesting, educational and valuable and feel confident that its achievements in the following areas are worthwhile:

- the scope of future studies in this areas has been identified
- a methodology has been established
- the life costs for an actual building have been evaluated
- the availability (or absence) of relevant data has been measured
- the pilot study has identified the issues and remaining problems
- a definition for cyclical renewal has been adopted, and a preliminary assessment made of an adequate allowance

At the same time, the study has been able only to draw tentative conclusions in some of the areas covered, and these will be subject to future verification. The Task Force was hindered by the limited amount of time for the study and by the lack of readily available data which would have made it possible to draw more statistically valid conclusions.

Specific conclusions and recommendations arising out of this preliminary study of building life costs, can be grouped into two main categories. These relate, firstly, to the study as a process for defining a methodology to acquire and utilize certain data on buildings, as a prelude to continuing and comprehensive studies which will assist universities in cost saving activities. Secondly, there are the comments which relate to the actual quantitative results obtained by the application of the life cost analysis to the selected building at the University of Windsor.

The conclusions and recommendations from the study as a process are listed below. They are accumulated here, because they arise from several sections of the report. Conclusions in the area of total life cost analysis for the Windsor case study, are contained in section 6.7, commencing on page 1.33, immediately following the description of the analysis. Conclusions from the HVAC analysis are listed in section 7.8, page 1.46, following the outline of the computerized study of the HVAC system.

Since this is only a preliminary study of the Law Building at the University of Windsor, i.e. an example of the use of techniques of analysis, the Task Force has made no recommendations concerning the design or operation of this specific building.

8.1 The Study as a Process

The Task Force feels that the following conclusions may reasonably be drawn from the work of the study.

Conclusion No. 1

It is possible to establish the total life cost for a building given the following items:-

(a) A definition of total life costs

(b) The actual construction costs with sufficient detail to identify the costs of various elements and sub-elements

(c) Maintenance and operating cost records in sufficient detail to identify costs for each of the operating and maintenance elements included in the definition of total life costs

(d) The life cycles of the building and its components

(e) Reliable cost indices for converting past actual capital, maintenance and operating costs to present costs

(f) A procedure for converting forecasts of future expenditures to the present value using appropriate discounted cash flow and inflation percentages

(g) A procedure for evaluating costs of cyclical renewal

(h) A simple computer program for establishing the total life costs with the above listed inputs and having the ability to quickly establish the range of values that may be found with different assumptions about escalation, discount rates, inflation rates, etc.

All of the above items have been investigated as part of this study and, where necessary, assumptions have been made and justified. It should be noted that the study investigated the availability of detailed operating and maintenance records. Comments on their present and future availability are to be found elsewhere in this report.

Conclusion No. 2

The calculation of a figure for the total life costs of a specific building is a worthwhile process for the following reasons:-

(a) It makes possible knowledgeable decisions concerning operating expenditure consequences of capital decisions, and vice versa.

(b) The availability of total life costs for a number of buildings would permit comparison of different building styles, usages, etc.

(c) The examination of total life costs enables one to establish the relative importance of various elements making up these costs.

(d) The total life cost analysis of many buildings will produce an invaluable data base, which would enable a thorough understanding of life costs to be obtained. This will assist in the forecasting of life costs for new buildings.

(e) The total capital and operating cost effect of user requirements can be evaluated during the planning and design process of a building. Such consideration of both costs is an advance over interpreting these requirements from the point of view of capital costs only.

Conclusion No. 3

The quantitative results of the study of life costs of the Law Building at the University of Windsor are valuable in that they are part of the process of understanding the subject. Obviously no statistical or general conclusions can be drawn from this one set of costs. A major task faces the university system in obtaining enough data to draw some general conclusions. Enough experience has been gained with one building to know that much time and some money will be required for this data compilation and accumulation process.

Conclusion No. 4

The study has uncovered a number of useful techniques for analyzing life costs. Included in these are the following:-

(a) Computer programs for studying heating, ventilation and air conditioning system efficiency in actual buildings or during the design process.

(b) The replacement cycle method for costing future building renovation and furniture and equipment replacements.

(c) A computer program calculating the present value of the total life cost and for comparing life costs when some of the input assumptions are varied.

Conclusion No. 5

By and large, a lack of data exists in the Ontario university system, on the following:-

(a) Operating and maintenance costs on individual buildings

(b) Actual data on true lifetimes of major elements of buildings

(c) Reliable indices to convert past construction, maintenance and operating costs to present cost levels

Conclusion No. 6

Based on a search of the available bibliography, it appears that little work has been done in Canada or elsewhere of direct application to the study. For example, no figure has been found which represents the total life cost as defined here.

Conclusion No. 7

One of the major problems in forecasting life costs in the remaining years of the building's life, is the effect of increasing age on items such as utilities, maintenance and housekeeping costs. While the Task Force has identified some tentative conclusions for some of these costs, any future study into the subject of life costs must thoroughly examine this problem.

Conclusion No. 8

The work of the Task Force would have been impossible without the use of consultants able to devote considerable time to the detailed work of data assembly, analysis, etc. A disadvantage faced by the Task Force, compared to, say, the Task Force on Building Costs, was the absence of a director or chairman able to spend periods of full time on the project. The Task Force feels that any further in-depth study of the subject of life costs must be able not only to call on the services of consultants, but also to be co-ordinated and guided by someone in a position to work full time for stretches at a time on the project.

Conclusion No. 9

Faced with ever tighter operating budgets, universities are urgently investigating ways and means of achieving savings in further operating and maintenance costs. This is evidenced by a series of information exchange sessions which have been held this year among the various physical plant staffs. The question therefore arises, in what way will this report help the universities. Without belittling the efforts already being made by the universities, the Task Force concludes that a better understanding of life costs and a greater availability of quantitative information on such costs, will help to assess the results of costs savings efforts more accurately and will provide a guide to the areas where the highest payoff for such efforts may be expected.

Conclusion No. 10

The Task Force attempted to establish a close correlation between elements of operating and maintenance costs and elements of construction costs. It was found however that any given operating or maintenance cost was affected by a large number of different building elements. It is only possible through means such as the Meriwether computer program to assess the effect of a change on a large number of cost elements.

Conclusion No. 11

Many of the features of a building and its operation, are the results of implementing the requirements of users. The study considered these requirements as valid. The Task Force feels that there is scope for a study of the validity of such requirements, particularly after further work in life costs makes it possible to judge user requirements from a total life cost viewpoint.

Conclusion No. 12

The joint representation on the Task Force, of MCU, and COU (CCF) and members of OAPPPA was useful. It contributed to a better understanding between the various groups, and made it easier to get certain data.

8.2 Recommendations Concerning the Study of Life Costs

Recommendation No. 1

The investigation of building life costs should be continued and completed, by a Task Force established for this purpose.

Recommendation No. 2

The Task Force should include the following specific items in its deliberations:-

(a) Further accumulate and analyze data leading to a more statistically valid assessment of cyclical renewal allowances

(b) Review the methodology and assumptions contained in this preliminary study

(c) Working with the universities, establish a framework for the reporting system required for the accumulation of operating and maintenance costs of individual buildings on an annual basis

(d) Working with Statistics Canada and any others involved, review the subject of construction cost indices from the point of view of whether it would be advisable or necessary to make indices available for all university locations in Ontario

(e) Set up a system for accumulating the necessary data to prepare an operating and maintenance cost index along the lines used in this study

(f) Develop a method of updating total life cost present values so that these are kept current year by year

(g) Initiate a study of the effect of the age of the building on the various elements of operating and maintenance costs

(h) Investigate user requirements as they affect the technical environment, i.e., heating, ventilation and air conditioning systems, electrical systems, finishes and building envelope.

(i) Prepare a "manual" which would accumulate information such as:

- how to use life cycle costing
- how to use HVAC simulation computer programs
- case studies
- annual data supplements with regular updates
- updated bibliography

(j) Determine how to make best use of technical groups, staff at universities and sub-committees, to help the Task Force

Recommendation No. 3

The Task Force should be provided with a director or chairman who is in a position to work full-time for certain periods during the work of the Task Force.

Recommendation No. 4

COU and/or MCU should investigate sources of research funds to assist in the work of the Task Force.

Recommendation No. 5

Sufficient funds should be allocated to carry out the study.

Recommendation No. 6

In the immediate future, each university should apply the techniques and methodologies outlined in this report, to reduce the life costs of existing and future buildings.

PART TWO
CYCLICAL RENEWAL

CYCLICAL RENEWAL

1. INTRODUCTION

The introduction of the Interim Capital Formula in 1969 came at the end of a decade in which enrolments had been rising steadily and rapidly. The main thrust of the formula was therefore directed toward providing additional new space to accommodate increased numbers of students and toward meeting concomitant requirements for site acquisition and development.

In 1970 and 1971, the Interim Formula was revised to take some account of the age and quality of buildings (the age-quality discount) and the need to alter and renovate buildings (the cyclical renewal allowance). These were important innovations but in a time of increasing enrolment they were regarded as secondary features of the formula, somewhat preliminary in nature and based on rather gross assumptions.

As enrolment and the size of physical plants stabilize, these secondary features become all important. The cyclical renewal allowance provides the only continuing source of capital funds for keeping the physical plant in good repair and for alterations to suit changes in use made necessary by enrolment shifts and changing academic requirements.

At the time of its introduction into the formula, the allowance was only defined in the most general terms and universities were not clear as to exactly what costs the allowance was intended to cover. In any case, each university was free, within its total formula entitlement, to use its allowance to renovate, alter or build new.

In view of its importance, therefore, the Committee on Capital Financing of the Council of Ontario Universities requested a group of members of the Ontario Association of Physical Plant and Planning Administrators to study problems related to cyclical renewal, and particularly, what costs are intended to be covered by the allowance, and the adequacy of the present annual allowance of 1% of the allocation inventory valued at $55 per net assignable square foot plus current cumulative formula cash flow.

In view of the study of total life costs for buildings, which includes items covered by the cyclical renewal allowance, it was considered desirable and, indeed, essential that the Task Force on Life Costs include in its work, an assessment of these problems related to cyclical renewal, and recommend a suitable level for the allowance.

This study of cyclical renewal has been made a part of a comprehensive report on building life costs, because of its relationship to these costs. However, this part of the report is a complete and self-contained statement on cyclical renewal. For this reason, it contains its own conclusions and recommendations.

At the outset of this report on cyclical renewla, it should be stressed that the terms of reference for this work, related mainly to the question of the adequacy of the current 1% allowance. This report does not comment on the adequacy of the $55 used in the formula to value each assignable square foot of space; this was the subject of recommendations in Building Blocks Volume 4.

The Task Force did not study the question of whether cyclical renewal funding should be separated from the overall capital formula, though conclusions have been drawn regarding the need for cyclical renewal funds irrespective of whether enrolment entitlement for any specific institution is positive, zero or negative.

In addition, the study did not investigate whether other, fundamentally different formulae or funding methods might not exist, to replace the present formula system.

The remaining portions of this statement on cyclical renewal will deal with its scope and definition, suggested methods of rational assessment of adequate allowances for its components, and will summarize the findings. The statement will conclude with a recommendation concerning the size of the present allowance.

The Task Force on Life Costs would like to acknowledge the work of Mr. Barry James, of Carleton University, who laid the analytical groundwork, on which much of the following work was based.

A copy of all survey responses and other basic data relevant to this analysis of cyclical renewal, is available in the offices of the Council of Ontario Universities, and of the Capital Support Branch, Ministry of Colleges and Universities.

2. SCOPE AND DEFINITION

At a meeting of the Ontario Association of Physical Plant and Planning Administrators held at Laurentian University on October 13, 1971, representatives of the Ministry of Colleges and Universities presented an informal working paper on certain aspects of the Capital Formula, including cyclical renewal. In this statement, the purpose of cyclical renewal was described in the following sentence:

"This additional allowance to the Formula inserts an amount each year into the total cumulative entitlement to cover the cost of alteration and allow for depreciation, obsolescence and eventual replacement."

A further meeting of OAPPPA representatives was held at the Skyline Hotel in Toronto on January 13, 1972 at which the proposed definition was further discussed. While this discussion dealt to a significant extent with the differences between maintenance and renovations, it was suggested that the ultimate replacement of buildings could not be covered by the then current formula.

The Task Force also considered this matter of replacement and decided that this item should not be included, because of the higher level of uncertainty regarding associated expenditures. The Task Force felt that a better way of handling this item was by reducing the university's allocation inventory, when a demolition is approved, which is the current arrangement.

One of the first tasks of the Task Force was to review the previous work on cyclical renewal and then to arrive at a statement of its scope. It was concluded that the cyclical renewal allowance should provide funds adequate to cover all costs related to physical facilities except the following:

(a) New facilities made necessary by increased university enrolment*, including initial furniture and equipment.

(b) Site acquisition and other costs presently covered by the non-formula portion of the interim formula

(c) Normal maintenance including minor repairs, which may be said to consist of all work operations or material expenditures related to the Physical Plant work operation to maintain the plant in good condition and achieve the life expectancy of the building element. Such work is funded from operating budgets.

Within this broad scope, the Task Force identified five costs of cyclical renewal which could potentially be included in a cyclical renewal formula. They are defined as follows:

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* funded through the enrolment component of the capital formula

(1) Renovations Component

Major repairs to and replacement of building elements, such as roofing, mechanical systems, made necessary by normal use and deterioration.

(2) Alterations Component

Remodelling to accommodate user requirements resulting from changes in occupancy, use or academic requirements.

(3) Code Component

Work involving extraordinary expenditures forced on a university by circumstances over which it has no control, when not carried out as part of another project under components 1 or 2. This might include alterations made necessary by changing code requirements or interpretations.

(4) Equipment Component

Replacement of major non-building equipment such as audio-visual, instructional and research equipment in scientific and other special purpose laboratories or spaces.

(5) Furniture Component

Replacement of furniture.

Of these, the Task Force considered the code component inappropriate for inclusion in a formula. It was felt that there would be few instances of alterations made necessary by changing code requirements or interpretations, which could not be planned as part of alterations and/or renovations projects. Where the appropriate authority was insisting on such changes being made at a time that did not fit in with another project in the same building, the Task Force felt that this could best be handled by special application for financial assistance.

Three of the four remaining components - renovations, equipment and furniture - required little justification for being included in a formula allowance, since the basic purpose of cyclical renewal is the periodic replacement of worn out components of physical facilities which are beyond economic repair.

However, there were arguments for both exclusion and inclusion of the alterations component. The main reasons why the Task Force favoured including this component in the formula allowance were as follows:-

(a) The need for alterations to accommodate changes in user requirements during some stage of a building's life, is highly predictable

(b) Many projects are mixtures of renovations and alterations, and it would not be practical to cover the cost of part of a project by formula, and part by a special non-formula allocation.

(c) The combined allowance for four components would be larger than one for three components only. This would provide a larger total source of funds from which each university could allocate portions to renovations, alterations and other projects as it judged appropriate.

(d) Inclusion in the formula tends to ensure availability of funds for alterations.

The main arguments against a formula allocation for alterations appeared to be:-

(a) The timing, scope and cost of each alterations project are highly unpredictable and hence not amenable to formula-type assessment.

(b) There is no method of evaluating the allowance on the basis of any rational assessment of future need (other than as an extrapolation of past expenditures, the method adopted by the Task Force)

(c) Alterations projects cater to changes in academic requirements, which are in themselves unpredictable and subject to non-forecastable pressures.

The above definitions of the components of cyclical renewal, can apply irrespective of the source of funds. While maintenance, by definition, is funded from operating funds, cyclical renewal projects are normally carried out with capital funds. However, the Task Force has heard of some sizable alterations and renovations projects at one or more universities, funded from operating funds. In any data used in the assessment of the adequacy of the current 1% allowance, such projects have been omitted.

However, in making projections of typical total life costs based on actual costs for a number of buildings, all cyclical renewal work must be included.

It should be pointed out that the word component as used in this report, refers to a part of the total cyclical renewal cost. It has been necessary to break this cost into these components for purposes of definition, and evaluation of their individual costs. It is not suggested that a component is necessarily synonymous with the definition of a separate capital project for approval purposes. It is expected that a typical cyclical renewal capital project might include elements of most or all of the components.

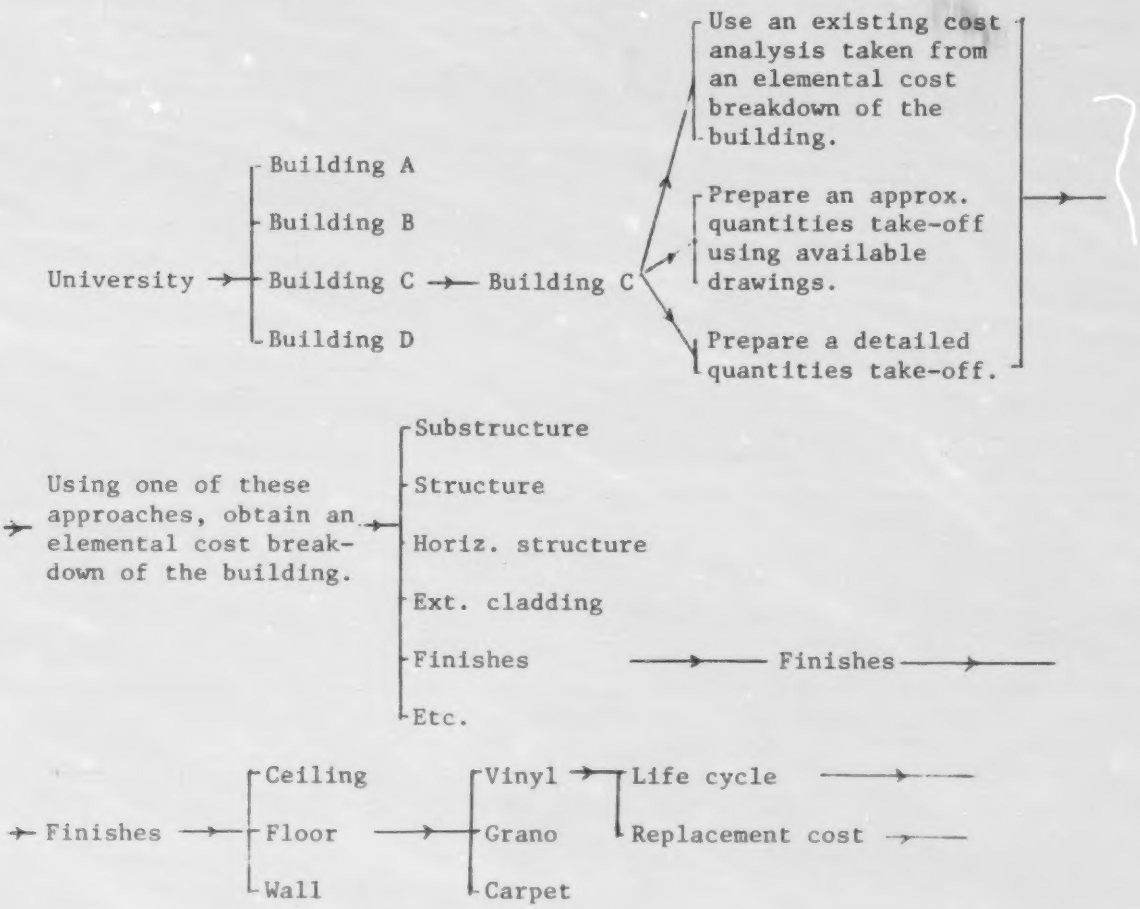
3. RENOVATIONS COMPONENT

The methodology used by the Task Force for this component, provides a means of assessing the funds required annually for major repairs to and the replacement of entire building elements such as mechanical systems, roofing, etc. made necessary by normal use and deterioration.

With this methodology, there are two approaches available, either the ideal approach which would demand a study at a high level of detail, or the simplified approach which was developed for this interim study.

3.1 The Ideal Approach

The following model represents the analysis and calculations that would have to be made in order for each university to arrive at an appropriate figure, which takes into account all of the existing differences between buildings, in terms of their age, original cost, design, usage, etc.


University
Building A
Building B
Building C
Building D
Building C
Use an existing cost analysis taken from an elemental cost breakdown of the building.
Prepare an approx. quantities take-off using available drawings.
Prepare a detailed quantities take-off.
Using one of these approaches, obtain an elemental cost breakdown of the building.
Substructure
Structure
Horiz. structure
Ext. cladding
Finishes
Etc.
Finishes
Finishes
Ceiling
Floor
Wall
Vinyl
Grano
Carpet
Life cycle
Replacement cost
]

→ Life Cycle →
- Age of component
- Use
- Exposure
- Present Condition

= say, 10 years left for existing finish, plus replacement at 15 year intervals thereafter.

→ Replacement Cost →
- Initial cost
- Removal cost
- Installation cost

= say $1000 during next X years of building life.

If the above analysis is carried out for all building elements, for the identical building life, the sum of such replacement costs would represent the total renovations cost for that building. The sum could be expressed as dollars per net assignable square foot per year by applying the correct factors. The resulting cost could be readily expressed as a percentage of the capital formula allowance of $55 per net assignable square foot, in order to compare it with the current cyclical renewal allowance.

It is obvious that the use of this ideal approach for establishing a university or system-wide allowance, was impossible because of the time necessary to look at each building at this level of detail. However, the approach can, and should, be used for individual buildings. The only step where judgement based on physical plant experience is used (as distinct from readily established cost and quantities data) is the one in which the remaining life and replacement cycles are established.

In work carried out on behalf of the Task Force, this judgement was provided only by experienced operating physical plant personnel. It might also be possible to obtain knowledgeable and useful inputs from contractors and sub-contractors, architects, engineers, etc., in order to obtain a more rounded-out result. However, lack of time precluded the use of these sources of data for this aspect of this study.

3.2 The Simplified Approach

This approach provides a quicker result, but aggregates many, varying buildings. The resulting percentage allowance is therefore less reliable as an indicator for any given building, but is more appropriate for use in judging the adequacy of the current allowance. The required amount of judgement is about the same as in the ideal approach, but it is applied to more composite elemental costs. For example, the wall sub-element of the structure element may be made up of some brick, some metal cladding, some precast concrete panels, etc. The life cycle figure arrived at in any given university on the basis of the judgement and experience of its physical plant staff, would represent an intuitive or weighted average for the mix of wall types existing only at that institution.

The simplified approach uses elemental capital cost data, which are generally readily available. Building Blocks Volume 4, The Report of the Task Force on Building Costs, contains this information for a number of buildings, in the required format.

The methodology can be summarized as follows:-

(a) an analysis is made of the average costs, expressed as percentages of the total project costs, for the major elements and sub-elements (sub structure, horizontal structural elements, cladding, interior vertical elements, etc.) of a selected number of buildings.

(b) each element and sub-element is examined to determine what percentage of the element will need to be replaced during the expected life of a building and at what age that percentage will be replaced.

(c) from (a) and (b) above, a profile of major renovation costs is built up, still expressing all costs in terms of percentages of project cost.

(d) from the profile obtained in (c), average annual percentage costs over each five or ten year interval of building life are obtained.

(e) the average annual percentage costs can be converted to cost per year per NASF using an appropriate unit cost factor (currently $55 per NASF is used).

(f) finally, the needs of any one university in any one year can be assessed from the known NASF and remaining life of each building on the campus of that university.

This theoretical approach was necessitated by lack of data and lack of time to obtain more data. In any case, only the older universities would be at all likely to have any records on major renovations. Table 6 which is on the following pages, shows the results of step (a) for the six university buildings whose building costs were analyzed in Building Blocks Volume 4. These are a representative sample selected from more than 40 university buildings. Physical plant staff at a number of universities were then asked to carry out step (b) on a typical building which would represent the construction norm for that campus. The percentage and age data from each of the six universities carrying out this exercise, were then applied to university average element and sub-element percentages from Table 6. The summary results of this are displayed in Table 7 on page 2.11. Detailed comparisons for each element are available at COU and MCU.

It will be seen that the six results fall into two separate groups, which indicate that this allowance should be either around 1% or around 2½%, compared to the present 1% for all components. It has not been possible to explain this wide variation between the otherwise very closely grouped results, on the basis of the age of the campus. A factor that may help to explain this discrepancy, could be each university's policy on the timing and accumulation of such work. This has not been investigated.

TABLE 6

ANALYSIS OF ELEMENTAL PERCENTAGES FOR THE SIX UNIVERSITY BUILDINGS*

Element/Sub-Element	Child Study Centre Ottawa	Law Bldg. Windsor	Crop Sc. Guelph	Petrie Sc. York	Wat M&C	Wat Eng.	Total	Univ. Ave.
Indirect and General	9.0	9.1	8.5	8.5	9.1	7.5	51.7	8.6
Substructure	3.0	4.3	3.5	1.2	3.3	4.0	19.3	3.2
Normal Fdns.	1.0	1.1	2.0	0.3	2.3	3.6	10.3	1.7
Basement Exc.	0.3	0.6	1.5	0.9	0.7	0.4	4.4	0.7
Special Fdns.	1.7	2.6	-	-	0.3	-	4.6	0.8
Horizontal Struct. Element	11.5	21.6	13.9	13.7	17.5	16.3	94.5	15.8
Slabs on grade	0.7	1.3	1.6	0.9	0.6	1.3	6.4	1.1
Floor & roof Constr.	9.6	17.5	10.9	10.8	15.7	13.1	77.6	12.9
Roof finish	1.2	2.8	1.4	2.0	1.2	1.9	10.5	1.8
Exterior Cladding	17.8	12.0	9.4	10.8	12.8	13.3	76.1	12.7
Walls below gd.	1.3	0.8	2.1	1.9	0.8	0.5	7.4	1.3
Walls above gd.	12.1	5.3	5.1	4.4	9.1	8.6	44.6	7.4
Windows	4.0	5.2	1.4	3.6	1.7	3.5	19.4	3.2
Ext. doors	0.3	0.3	0.5	0.2	0.3	0.1	1.7	0.3
Projns. balcs.	0.1	0.4	0.3	0.7	0.9	0.4	2.8	0.5
Interior Vert. Elmts	6.8	7.0	4.3	7.9	8.6	7.1	41.7	7.0
Partitions	4.7	4.8	3.1	6.2	6.2	5.6	30.6	5.1
Folding Ptns.	0.4	1.0	0.2	0.1	0.2	0.2	2.1	0.4
Doors	1.7	1.2	1.0	1.6	2.2	1.3	9.0	1.5
Multi-Storey Elmts.	4.2	2.9	1.6	2.3	3.1	1.6	15.7	2.6
Stairs	2.3	1.8	0.3	0.6	1.2	0.6	6.8	1.1
Catwalks	-	-	0.1	0.1	0.1	0.2	0.5	0.1
Elevator Hoists	1.9	1.1	1.2	1.6	1.8	0.8	8.4	1.4
Escalators	-	-	-	-	-	-	-	-

* Figures represent the size of each element and sub-element, expressed as a percentage of total construction cost

Source: Building Blocks Volume 4

TABLE 6 - Continued

Element/Sub-Element	Child Study Centre Ottawa	Law Bldg. Windsor	Crop Sc. Guelph	Petrie Sc. York	Wat M&C	Wat Eng.	Total	Univ. Ave.
Interior Finishes	9.3	9.8	4.9	4.2	7.3	5.3	40.3	6.8
Floor finishes	3.6	3.7	1.6	1.2	2.8	2.3	15.2	2.5
Ceiling finishes	3.6	3.4	1.9	1.7	2.5	2.2	15.3	2.5
Wall finishes	2.1	2.7	1.3	1.2	2.0	0.8	10.1	1.7
Special finishes	-	-	0.1	0.1	-	-	0.2	0.1
Fittgs. Fixt. Equip.	3.0	2.8	7.8	12.3	3.2	8.2	37.3	6.2
Non-Instruction	2.6	1.3	0.3	1.7	2.0	2.4	10.3	1.7
Instructional	0.4	1.5	7.5	10.6	1.2	5.8	27.0	4.5
Cash Allowances	2.6	1.6	0.9	1.8	2.5	1.8	11.2	1.9
Hardware	2.0	1.3	0.8	1.6	2.3	1.5	9.5	1.6
Testing & Inspection	0.6	0.3	0.1	0.2	0.2	0.3	1.7	0.3
Plumbing & Drains	5.7	2.6	6.2	6.1	3.8	5.0	29.4	4.9
Roughing-In	2.7	2.0	1.5	1.4	2.3	1.5	11.4	1.9
Roughing	1.1	-	0.9	1.2	-	0.5	3.7	0.6
Plumbing Fixt.	1.0	0.5	0.3	0.2	0.8	0.3	3.1	0.5
Plumbing Fixt.	0.4	-	0.1	0.1	-	0.1	0.7	0.1
Fire Protection	0.5	0.1	0.4	0.7	0.7	0.4	2.8	0.5
Special Serv.	-	-	3.0	2.5	-	2.1	7.6	1.3
Heating, Vent. Air Cond.	14.6	16.2	23.2	18.2	15.8	16.7	104.7	17.3
H.V.A.C.	14.6	16.2	14.5	13.8	14.0	14.5	87.6	14.5
Special Systems	-	-	8.7	4.4	1.8	2.2	17.1	2.8
Electrical	12.5	10.1	15.8	13.2	13.0	13.2	77.8	13.0
Transformer & Wiring	1.6	2.8	6.2	1.7	2.9	1.1	16.3	2.7
Lighting & Wiring	4.8	4.8	5.7	5.7	6.3	5.0	32.3	5.4
Underfloor Duct System	-	-	0.5	0.6	1.6	0.6	3.3	0.6
Special Systems	6.1	2.5	3.4	5.2	2.2	6.5	25.9	4.3

Table 7

ESTIMATED % OF CONSTRUCTION COSTS[1] REPLACED IN "THEORETICAL" BUILDING

University	Percentage of first cost of building replaced At 10 Years	At 20 Years	At 30 Years	At 40 Years	At 50 Years	Total 50 yr % Replace't	Average Annual % Replaced	Adjusted Annual (%) on $55/NASF
Carleton	21.49	27.38	37.54	24.63	26.60	137.65	2.75	2.67
Guelph	12.86	28.52	39.44	36.42	17.72	134.96	2.70	2.35
Waterloo	6.03	10.89	14.81	19.85	7.89	59.47	1.19	1.04
Western	3.72	12.79	8.73	31.51	4.09	60.84	1.22	1.06
Windsor	21.35	26.48	25.08	30.95	29.59	133.46	2.67	2.32
York	7.14	12.56	9.71	14.27	12.19	55.86	1.12	0.97
Average	12.10	19.77	22.55	26.27	16.35	97.04	1.94	1.69

1. Includes estimates of indirect and general costs, professional fees, contingencies; excludes furniture and equipment costs.

2. Average % replaced corresponds to gross construction cost which excludes costs of furnishing and equipment. Adjusted allowance is % allowance on $55/NASF valuation which includes furnishing and equipment allowance at 15%.

3. Percentage of first cost of building replaced represents the sum for all elements of the building, of the % of each element replaced in each of the stated years multiplied by the % which the element forms of the first cost of the building.

Source: Survey responses on file at COU and MCU

In summary, and using only the lower figure, it can be seen that this approach suggests that the renovations component should be in the order of 1%, which equals the current allowance for all components.

Independently of this approach, the actual Law Building at Windsor was processed in the same way, with a resulting figure of 1.1% for the adjusted allowance based on $55 per NASF. (See Appendix 4)

On this basis, the Task Force concluded that a 1% allowance for the renovations component, appeared to be reasonable, pending the results of the assessment of a number of actual buildings. This compares with the current 1% allowance for all components.

4. ALTERATIONS COMPONENT

The object of the following analysis is to assess the funds required annually for remodelling to accommodate user requirements resulting from changes in occupancy, use, academic requirements. The Task Force found no theoretical approach to reach this objective and decided that the best assessment possible would be one based on available and appropriate historical data.

Information on funds actually allocated to alterations could be made readily available from data on individual projects in the files of the Ministry of Colleges and Universities. However, this source was not used, since it was found impossible, in most cases, to break out of total project costs, the portion used for alterations. The Task Force therefore requested specific data from each university, as noted in Appendix 3, Requests for data on funds spent by Universities on Alterations (Cyclical Renewal) Projects.

The methodology adopted was as follows:-

(a) Establish the total dollar value of all (and only) alterations projects (or of alterations portions of projects) per year for a number of years, for each campus.

(b) Divide this annual amount by the total campus assignable square footage applicable in that year, to obtain a figure for the dollars per NASF per year, for a series of years, for each campus.

(c) Obtain a university system-wide average per year

(d) Express this average, as a percentage of $55, in order to compare the figure thus derived, with the current 1% allowance for all cyclical renewal components.

Submissions of requested data were received from 11 of the 14 provincially-assisted universities in Ontario: Brock, Carleton, Guelph, Laurentian, McMaster, Ottawa, Trent, Waterloo, Western, Windsor, and York. The data covered the period from 1965 to 1972 approximately. The universities were requested, where necessary, to estimate the portion of a total project cost which corresponded with the stated definition of alterations, as opposed to the remaining components such as renovations, alterations due to changing building code requirements and so on.

The submission from Ottawa was not used in the analysis because of an apparent lack of differentiation between the renovations and alterations components. Universities found it difficult to indicate the proportional expenditures, for a given project, allocated to alterations versus the other components, but rather tended to classify a project as either entirely one or the other. From examination of the project descriptions, this approach generally appeared to be suitable for our purposes, and the analysis only includes the alterations projects.

In the case of McMaster University, it was not possible to use this approach. 33 of the 50 projects submitted by McMaster were classified as wholly renovations projects. In terms of total expenditures, these projects accounted for $1,364,413 of a total of $2,618,182 spent through the period, or approximately 52%. Needless to say, the omission of these projects, which probably included some amount of alterations, should result in a downward bias in the derived estimate of the allowance for the alterations component of cyclical renewal. Throughout the exercise, this approach was maintained. In view of the quality of data, it was considered desirable to derive a minimum estimate for which a reasonably high degree of confidence could be attached.

Table 8 on the following page presents a summary of the expenditures per net assignable square foot on alterations projects for each responding university through the period studied. Detailed submissions and tabulations, which formed the basis for Table 3, are available.* The figures provided in brackets indicate the known additional expenditures from non-capital formula funds on this component of cyclical renewal, where universities supplied this information. As shown, the expenditures vary considerably both among the universities and through time. While many submissions identified certain periods as "unusual", it remains difficult from examination of the data, to identify any period of normal activity. For this reason, no attempt was made to smooth the data (i.e. eliminate unusual points). Instead, an attempt was made to derive an estimate of the allowance which might be deemed suitable at a system level.

The total figures presented on Table 8 need some explanation. At first glance, the figure for 1965, 0.36, appears low given the high values assigned to Brock and Carleton. The reason for the lower estimate at the system level is a result of the zero expenditures at McMaster, Western and York. That is, the NASF of these universities have been included in the denominator of the ratio while no expenditures have been added to the numerator. This is compatible with the concept that a system allowance should be derived. The derived estimate would probably be inadequate for a given university at a specific point in time. Only through the long term could the allowance, if accumulated, be suitable for a given university.

Figure 2 on page 2.16 is a graph of the expenditures per NASF for alterations through the period examined. The solid line shows the capital funded expenditures only and indicates a fairly steady expenditure through the period. The dotted line indicates the total expenditures, including operating fund projects. These appear to have wider variations from year to year. On the basis of total expenditures, an allowance between $.32 and $.39 is indicated as necessary to permit continuation in the future, of past levels of expenditures on alterations. These figures are equivalent to 0.58% and 0.71% for this component alone, compared to the present allowance of 1% for all components.

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* in the offices of COU and MCU

Table 8

MCU CAPITAL FORMULA EXPENDITURES PER NASF

FOR ALTERATIONS PROJECTS

University	1965	1966	1967	1968	1969	1970	1971	1972	Reported Annual Average
	$	$	$	$	$	$	$	$	
Brock	1.34	5.56	9.89	3.40	3.29 (0.13)	0.0 (0.43)	0.0 (0.11)	0.0 (0.03)	2.94 (0.18)
Carleton	2.79	1.26	0.85	0.33	0.19 (0.04)	0.46 (0.08)	0.49 (0.10)	0.18 (0.05)	0.82 (0.07)
Guelph	0.0	0.0	0.0	0.33	0.61	0.08	0.42	0.21	0.25
Laurentian	n.a.	0.64	0.27	0.23	0.72	0.24	1.21	0.25	0.57
McMaster(1)	0.0	0.0	0.30	0.02	0.02	0.02	0.68	0.19	0.15
Trent	n.a.	0.94	2.06	0.31	1.33	0.39	0.14	0.26	0.78
Waterloo	0.12	0.11	0.0 (0.37)	0.13 (0.18)	0.07 (0.27)	0.37 (0.40)	0.14 (0.44)	0.34	0.16 (0.33)
Western	0.0	0.0	0.20	0.0 (0.14)	0.0 (0.48)	0.0 (0.28)	0.22 (0.29)	0.54 (0.13)	0.10 (0.26)
Windsor	n.a.	n.a.	n.a.	0.23 (0.06)	0.35 (0.03)	0.28 (0.08)	0.48 (0.33)	0.80 (0.05)	0.43 (0.11)
York	0.0	0.0	0.23	0.16	0.27	0.48	0.64	0.38	0.27
TOTAL(4)	0.36	0.26	0.38 (0.06)	0.25 (0.06)	0.32 (0.14)	0.21 (0.14)	0.43 (0.15)	0.36 (0.04)	0.32 (0.10)

Source: Survey material available at COU and MCU

(1) The estimates attributed to McMaster are downward biased, and therefore the total figures may also be downward biased. (See text)

(2) Bracketed figures represent known expenditures/NASF from operating funds. They are not included in the unbracketed figures.

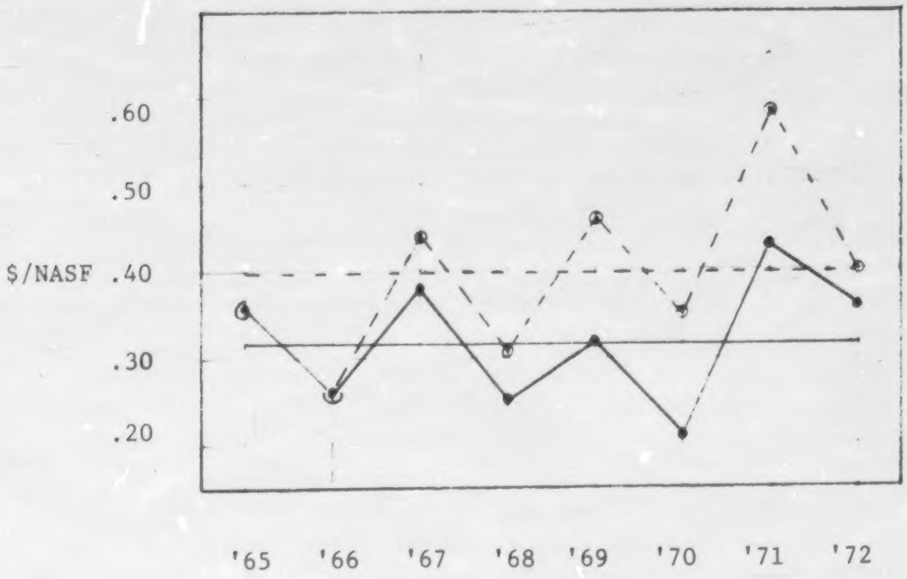
(3) n.a. = not available

(4) $/NASF for all universities who reported in that year, even if their expenditure is shown as 0.0

FIGURE 2

SYSTEM EXPENDITURES ON ALTERATIONS

(based on data from 10 universities)



—— Capital expenditures only

--- Capital and operating expenditures

Straight lines are calculated "least squares fit"

Source: Table 8

There are five final points to be made with regard to the derived estimate. First, the allowance has been derived supposedly at a system level, and yet Lakehead, Queen's and Toronto have been omitted. The Task Force was unable to guess at the effect on the results, if data from these three institutions had been included.

Secondly, the amount and costs of alterations work cannot be discussed without reference to users' requirements. In other words, this study did not answer such questions as: would it have been possible to spend less on alterations during the years 1965-1972, if users had requested fewer office partitions, less laboratory benching and utilities outlets, less rigid control on environmental conditions, etc.? Such a study of users' requirements and their justification is an enormous undertaking and might be the subject of a future report.

Thirdly, this assessment was carried out during a period of significant university expansion. The Task Force was not able to identify what effects other conditions of growth or stability would have on this component.

Fourthly, the reported costs of alterations included some furniture and equipment in many cases. Since this report identifies and recommends separate allowances for these, some reduction in the calculated alterations component was necessary to eliminate these costs. This has been done by reducing the figures by 13% to 0.51% and 0.62% since this is the percentage of total project cost devoted to furniture and equipment when these are assessed as 15% of the construction cost.

Finally, no account has been taken of escalation of construction costs in the period 1965-1972. There was probably a 35% increase in costs of new construction during that period. This means that the alterations work carried out in 1965 would probably have cost about 35% more in 1972 dollars than the actual figures used in the analysis. This would make the results of our analysis lower than they should be.

The Task Force has therefore concluded that an allowance for the alterations component of 0.51% would be adequate, pending confirmation of an appropriate figure through further review of alterations costs.

5. EQUIPMENT COMPONENT

Purchases of teaching, scientific and research equipment can take place in a number of circumstances, including the commissioning of a new building, the introduction of a new academic program, the start of a new research project, as well as the replacement of worn out or obsolete equipment. It is difficult to separate from the total cost of equipment purchases, those that are due only to replacement of worn out and unrepairable equipment.

The Task Force attempted to arrive at a figure for an allowance to cover this replacement in the following way:-

(a) Analyze a list of equipment purchased for a specific new build[illegible]ect, listing equipment by type and cost

(b) Using experience of purchasing department personnel, technicians, equipment users, etc., assess the useful life of each piece of equipment or type of equipment

(c) Assuming a building life of, say, 60 years, assess the total cost of replacing each equipment or group of equipment the appropriate number of times during the building life

(d) Divide the sum of all the replacement costs in the 60 years by 60 to arrive at an average annual dollar requirement

(e) Express this as a percentage of the initial cost, and compare the result with the current cyclical renewal allowance of 1%

It should be noted that the average annual dollar requirement for a given building has little significance on its own and should only be used in conjunction with similar figures for a number of other buildings at different stages in their replacement cycles, since there is little replacement likely in the first few years.

The above analysis was carried out on the following buildings, with the average annual replacement allowance as noted.

Building	Av. Annual % Replacement
Faculty of Law, University of Windsor	2.8
University Library, University of Windsor	16.0
Mathematics Bldg., University of Windsor	17.6
St. Patrick's College, Carleton University	14.0
School of Architecture, Carleton University	14.3
Arts 1, Carleton University	13.3

The source for these data is on file at COU and MCU.

It has not been found possible to explain the low figure obtained for the Law Building, which does not fit into the pattern of results obtained from the rest of this group of buildings. Because of this discrepancy, the Task Force decided to discard the percentage, until such time as results from a large number of such analyses demonstrated the complete range of values.

In order to compare these percentage figures with the cyclical renewal allowance, the equipment replacement percentages must be factored by a percentage representing a percentage that equipment purchases form of total project costs. This varies considerably, as noted in the M.C.U. publication "University Buildings Space/Cost Data". No firm figures are available for equipment alone, but equipment and furniture together can be assumed to vary between approximately 15 and 18%. A separate analysis of actual expenditures on furniture and equipment at the University of Guelph during its period of major expansion of both lightly serviced and heavily serviced buildings, shows that approximately 6% of total project expenditures were devoted to equipment*

Applying this factor to the percentages noted above indicates that the cyclical renewal allowance for the equipment replacement component would lie somewhere between 0.80% and 1.06% compared to the 1% for all components.

A number of qualifications must be noted concerning the validity of this analysis, as follows:-

(a) The analysis assumes that all equipment remains in use and is in fact, replaced at the stated intervals. This assumption is certainly open to question since a tour of many university buildings will quickly bring to light many items of equipment which have been patched up or are obviously old and beyond their useful life.

(b) The analysis does not take into account the effect of new equipment purchased at the time that renovations and/or alteration projects are carried out in the building. Such equipment may well replace existing worn out equipment, as well as providing equipment of a new type or function.

(c) Since no historical data is available on actual experience of the replacement of equipment due to use and obsolescence, we have had to utilize the judgement of purchasing departments and technical staffs. It could well be argued that a certain amount of "wishful thinking" is included in the equipment life cycles established in this way.

(d) Salvage value, if any, has not been taken into consideration, because of lack of data.

The net effect of these four qualifications is obviously to reduce the calculated percentage figures.

Bearing in mind the above considerations, the Task Force concluded that an interim allowance of 0.80% would be adequate for this component. This figure is at the low end of the range, but further analysis should be carried out to confirm a more permanent allowance.

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* figures are on file at COU and MCU

It should be noted that the cost of equipment (and furniture) is usually included in the total project cost of renovations and/or alterations projects. The Task Force has avoided any possible duplication of allowances. The renovations component methodology excludes consideration of furniture or equipment. The alterations component has been factored to eliminate such costs.

The Task Force has analyzed the costs of equipment replacement from the viewpoint of total life costs, since this has been its main concern. It is acknowledged that this increases the suggested size of an adequate allowance for this component of cyclical renewal costs, over that which would be adequate for equipment covered by a literal interpretation of the current provincial policy in this matter. This is contained in a letter dated March 26, 1968 from the then Deputy Minister of University Affairs to all university presidents. On page 6, included in a list of definitions of projects eligible for capital support, is the following:

"Cost of initial furniture, furnishings and equipment, when invoiced within twelve months of substantial completion of a new building, or an addition to an existing building or completion of a new space which becomes available as a result of the renovation or alteration of an existing building or unused space in a new building".

It is clear from this that, in the past, capital support for equipment has been based on its need for new, renovated or altered space, not on its need to replace obsolete or worn out equipment per se. However, in practise, it would not be possible to differentiate, in the case of individual, provincially approved renovations/alterations projects, between these two categories of need. In many instances, a piece of new equipment might well meet both needs.

It would be logical to suggest that equipment be treated in the same way, say, as a building roof, and that its replacement at the end of its useful life (e.g. when no longer economically repairable) be treated in the same way as the replacement of the roof, which is covered by capital support. It follows that an appropriate adjustment should also be made to the operating funds formula, which implicitly or explicitly, now provides for such replacement.

The Task Force has not assessed the cost of equipment replacement which occurs only for reasons of obsolescence and which is not in practise combined with the need for initial equipping of renovated or altered space.

6. FURNITURE COMPONENT

In the absence of historical data covering costs of replacement of furniture which is worn out and beyond repair, the Task Force decided to establish a theoretical allowance for such replacement using methodology similar to that developed for the equipment replacement component, as described in the previous section.

A number of buildings were analyzed in this fashion, with the following results:-

Building	Av. Annual % Replacement
Faculty of Law, University of Windsor	5.9
University Library, University of Windsor	5.5
Mathematics Bldg., University of Windsor	6.2
St. Patrick's College, Carleton University	8.4
School of Architecture, Carleton University	10.5
Arts 1, Carleton University	7.0
Petrie Science, York University	7.4

The source for these data is on file at COU and MCU.

The University of Guelph analysis, already referred to for equipment, indicates that furniture is slightly above 6% of total project costs. On this basis, the above percentages can be translated to be between .36% and a high of .63% compared to the current 1% for all components.

Qualifications similar to those described for equipment, including the comments on replacement for obsolescence, apply to furniture.

The Task Force concluded that an interim allowance of 0.36% would be adequate for the furniture component, pending the results of analyzing many more buildings by this method.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The following conclusions have been drawn from the foregoing assessment of the various components of cyclical renewal.

Conclusion No. 1

The Task Force has found that it is possible to estimate the costs of the components of cyclical renewal on the basis of technical considerations, but that the validity of the results of the estimation process varied between the components. This is due to the lack of time to obtain more data and do more case studies, and unavailability of relevant data, in some areas.

Conclusion No. 2

The assessment method for the renovations component can easily be refined and made more valid, by increasing the number of actual buildings analyzed in this method. Building up a body of data based on actual buildings is considered to be more valid than the approach adopted by the six universities assessing this component on the basis of a theoretical and composite building.

Conclusion No. 3

For the alterations component, the Task Force has attempted to arrive at an estimate of an adequate cost allowance on the basis of actual costs allocated to this component by Ontario universities in recent years. The Task Force considered this approach the best one possible at this time, but realized that the results can be questioned on three grounds as follows:-

(a) Not all Ontario universities responded to the survey in which the evaluation of an allowance was based

(b) It is difficult to separate out realistically, the alterations costs in many projects from those costs more attributable to renovations and code requirements

(c) The amount of money actually spent by universities on alterations work has been significantly influenced by the general economic situation, the rapid growth in the amount of new space available, total funds allocated by the province to universities in general, and to a number of other non-technical factors.

Conclusion No. 4

Subject to the qualifications noted in the discussion of the assessment process, the average annual replacement costs for equipment and furniture are indicative of the level of allocation that should be made in order that these resources be maintained at an adequate level of service.

Conclusion No. 5

The Task Force has found that the combined costs of the components appears to be between approximately 2.7% and 4.7% and that the current 1% allowance appeared therefore to be insufficient.

This is based on the following component allowances for each of which the low and high value resulting from the assessment method, are provided.

	Low	High
Renovations	1.00%	2.50%
Alterations	.51	.62
Equipment replacement	.80	1.06
Furniture replacement	.36	.50
Total for components	2.67%	4.68%

Conclusion No. 6

The percentage allowances noted in Conclusion No. 5 are adequate to ensure a normal life for a mix of buildings in the future, but assume that they are already at a relatively acceptable standard. The Task Force did not study the adequacy of the age-quality discount for bringing old, unrenovated buildings up to this standard.

Conclusion No. 7

The Task Force did not find in the bibliography any reference to an analysis of cyclical renewal along the lines that has been attempted or of a comprehensive figure for a suitable annual allowance for such costs. This is understandable, since universities have only recently been faced with a formula allowance for such work. In contrast, the owners of commercial office buildings would generally not be involved with recovering the costs of alterations and furniture and equipment replacement since these are tenant costs. It is possible that major repair or renovation costs have been published for such buildings and this might be a suitable investigation as part of any further work done on the subject of cyclical renewal.

Conclusion No. 8

The analysis of cyclical renewal allowances was aimed at evaluating an adequate % figure for use in the current capital formula which is used to assess a university's entitlement for future cyclical renewal funds. No conclusions can be drawn from this work on the validity of the formula method itself, or of the advantages of any other methods of evaluating funds required or to be made available.

Conclusion No. 9

Universities are concerned with the total dollars available to them for cyclical renewal. This amount is affected not only by the percentage allowance, but also by the value attributed to the space inventory, and the inventory base used in the formula. All factors will require assessment from time to time, if universities are to be enabled to maintain their present space, which is valued at about $1 billion in the current formula.

Conclusion No. 10

The adopted methodology relates to all the elements and contents of actual buildings and the findings on cyclical renewal formula allowances apply to the whole building. It would not be logical to apply these allowances to the building, after its valuation base has been reduced by the one time age-quality discount.

Conclusion No. 11

In terms of the general applicability of the adopted approach to cyclical renewal, the Task Force concluded that the concept of one composite percentage allowance was valid for the Ontario university system irrespective of the age spectrum of each campus.

It could be argued that an "old" campus required more cyclical funds per NASF, than did a new campus having no building older than 7-10 years. However, the Task Force interpreted the age-quality discount applied to the actual space inventory, as representing a one-time allowance or generator of funds entitlement, whose purpose was to enable old buildings to be brought up to some acceptable standard of accommodation and utilization. From then on, the cyclical renewal allowance would be designed, and should be sized, to generally maintain this standard over the long term. Thus the actual age of buildings on a given campus is irrelevant to the assessment of a cyclical renewal allowance for that campus, provided that the capital formula also included the age-quality discount mechanism.

While buildings are still new (say less than 10 years old), the Task Force acknowledges that there should be no need for major replacement or renovation, and little alteration. However, it should not therefore be concluded that cyclical renewal allowances are not required in the early years. The methodology adopted by the Task Force averages costs occurring at intervals of, say, 10 or 20 years, over each year of the building life. Thus, entitlement would be generated in the early years (though funds not necessarily spent) to permit a sizable expenditure in, say, the 10th or 20th year.

7.2 Recommendations

On the basis of the above conclusions, the Task Force makes the following recommendations on the subject of cyclical renewal.

Recommendation No. 1

For the purposes of the capital formula, the term cyclical renewal should cover the four components - renovations, alterations, equipment and furniture - as defined in this report.

Recommendation No. 2

The methodology employed by the Task Force should be used as a basis for the derivation of an appropriate allowance for cyclical renewal.

Recommendation No. 3

On the basis of the conclusions drawn from the data and methodology used by the Task Force, consideration should be given to increasing the current allowance for cyclical renewal.

Recommendation No. 4

MCU policy regarding the funding of equipment and furniture replacement for reasons of obsolescence should be changed, to include this under the conditions of the capital formula, with appropriate modification to the operating formula.

Recommendation No. 5

There should be annual reassessments of the values of all the parameters used in the cyclical renewal entitlement calculations, i.e. the percentage allowance and the dollar per square foot allowance, in order that the universities can properly maintain their facilities in the face of general price increases.

Recommendation No. 6

All universities should be urged by the Council of Ontario Universities and the Ministry of Colleges and Universities to devote sufficient time and money to derive a more detailed analysis of the cost of the components identified by the Task Force and particularly to a more detailed analysis of alterations costs.

Recommendation No. 7

A further task force including a membership drawn from the universities, the colleges, and the Ministry be established in order to carry out more investigations of cyclical renewal costs particularly the study of more actual buildings in order to better assess renovations, equipment and furniture replacements, and the necessary modification resulting from Recommendation No. 4.

Recommendation No. 8

The cyclical renewal allowance should apply to the entire space inventory of an institution including leased space, albeit at a reduced level* The appropriate reduction in the level of the allowance for leased space should be a subject for study by the Task Force referred to above.

Recommendation No. 9

Projects involving only the code component should be reviewed and approved by the Ministry on a project by project basis outside the cyclical renewal formula. It is to be expected that in most cases such work would be made part of a project involving other alterations and/or renovations.

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* Excluding residential space

Recommendation No. 10

The cyclical renewal formula should not include reference to the demolition of buildings. This should be handled by an appropriate reduction in the university's allocation inventory.

PROPOSAL FOR PILOT STUDY INTO LIFE COSTS OF BUILDINGS AND THEIR RELATIONSHIPS TO INITIAL CONSTRUCTION COSTS

1. Background

During the past several years, a number of studies have been carried out within the Ontario University system in the general area of capital facilities. These studies have aimed at establishing what are the appropriate capital facilities required by the system for proper functioning and at ensuring the most effective utilization of the financial resources allocated to the provision of these facilities.

Examples of such studies that have already been completed, include the:

- Ontario Universities Physical Resources Survey (Taylor, Lieberfeld and Heldman study)
- University Buildings Space/Cost Data (Ministry of Colleges and Universities report)
- Building Blocks, Volume 4 - Report of the Task Force on Building Costs (Council of Ontario Universities)

Despite the wide scope of this completed work, and the current restriction on the construction of new facilities, there remain areas where further study and understanding of initial and life costs of buildings will be of help to all segments of the University system. Both the Universities, through C.O.U., and the Ministry of Colleges and Universities have suggested more detailed areas of study in this general topic. These studies would aim to provide information which will:-

(a) assist universities to obtain maximum economic utilization from the present facilities

(b) assist in making policy decisions concerning the most efficient way of providing future physical facilities

It is in this context of several but related studies, that this proposal is made for a pilot study into life costs of buildings and their relationships to initial construction costs.

2. Introduction

This proposal has been prepared by a Task Force, consisting of members of the Ontario Association of Physical Plant and Planning Administrators, and representatives from the Ministry of Colleges and Universities. The proposal responds to a request from the Council of Ontario Universities and its Committee on Capital Financing, which arose from the review by C.O.U. of the report "Building Blocks, Volume 4 - Building Costs" and, in particular, from Recommendation 5:

> "The second phase of the study should be immediately implemented to include the study of life costs, including costs of maintenance, operations and change, and to analyse the validity of programmatic needs that result in higher design requirements and higher cost elements for buildings."

The study would also provide answers to some of the questions raised in the document "Building Life Cost Study Outline", attached to this proposal for information. This was tabled by M.C.U. at a meeting of the Joint C.O.U./C.U.A. Sub committee on Capital Support on December 4, 1972. These are the questions in the document relating to existing facilities, and their life costs of operation, systems replacement and change of use. The members of the Task Force felt that these were priority matters, while the other matters raised in the M.C.U. outline (which relate to future physical facilities) could be left until the completion of the currently proposed work.

The Task Force has met on four occasions (October 24, November 13, November 22, December 19) to consider this and closely related matters and to prepare this proposal.

3. Feasibility of Study into Life Costs of Buildings

In their discussions on the various aspects of the proposed study, it became evident to the Task Force that exploratory work should be carried out before a proposal for a full scale study into life costs of buildings could be prepared. Also resources such as the time of the Task Force members or funds for consulting services, could only be committed effectively after some further investigation.

Among the reasons for recommending a pilot study before commencing a full scale study, were the following:

(a) the problems involved in acquiring the necessary data were not fully clear

(b) definitions of life costs must be agreed and then tested for practicability against probable information availability

(c) little prior work in this area of study appears to be available

(d) it would not be possible to reliably assess the cost and duration of the full scale study, with only presently available information

The Task Force has therefore agreed that only limited studies should be carried out initially, restricted to establishing the feasibility of more comprehensive studies.

The remainder of this document relates to this pilot study, rather than to a comprehensive study.

4. Objectives of A Pilot Study

The essential objective of this study is to evaluate the detailed problems and costs of carrying out an extensive study of the life costs of buildings and their relationships to initial building costs. This evaluation can be done, it is felt, on the basis of relevant information derived from an in-depth analysis of one carefully selected building and of a small number of selected life cost elements for several buildings.

There are two distinct phases in this pilot study, one relating to definitions and data analysis (Phase A) and one dealing with the problems of comparability and justification (Phase B). In more detail, the objectives of these two parts of the study are as follows:

Phase A

1. To define the "life costs" of a building.
2. To establish the potential difficulties in obtaining reliable data on life costs for an individual building.
3. To gain an understanding of, and develop a methodology for measuring and analyzing, the relationship of life costs of a building to its original construction cost.

Phase B

To compare for two or more buildings:

1. One or more selected items of life costs, and,
2. the construction cost of those building elements which have significant effect on these life cost items

in order to establish the nature of the justification for particular building element designs.

5. Methodology

It is proposed to proceed as follows:

(a) Review of literature

Phase A

(b) Selection of building:

- (i) establish desirable characteristics of selected building
- (ii) make selection

(c) Prepare comprehensive definition of "life costs" and identify measurable and/or significant elements of life costs.

(d) Make qualitative assessment of probable relationship between each element of building design and each element of life cost.

(e) Obtain readily available data on annual operating and maintenace costs.

(f) Arrange for necessary analyses, estimates, studies, checks, etc. to obtain remaining items of life costs on annual or other basis.

(g) Analyze life cost data and make necessary assumptions, calculations and extrapolations, etc., in order to arrive at life cost.

Phase B

(h) Selection of buildings to be compared:

- (i) establish desirable characteristics of selected buildings
- (ii) establish number of buildings to be used in feasibility study
- (iii) make selection

(i) Selection of life cost elements to be compared:

- (i) establish desirable characteristics
- (ii) make selection of life cost items

(j) Obtain data on selected life cost elements for selected buildings and relate to appropriate building design element by both description and cost.

(k) Establish specific options in building design available to the designer and assess likely changes in life cost element if these options had been used, other things remaining equal.

(l) Evaluate justification for actual design element used.

Phase A and B Combined

(m) Draw conclusions and make recommendations on:

- (i) Comprehensive study of life costs
- (ii) Methodology to be used for such a study

There are two distinct phases in this pilot study, one relating to definitions and data analysis (Phase A) and one dealing with the problems of comparability and justification (Phase B). In more detail, the objectives of these two parts of the study are as follows:

Phase A

1. To define the "life costs" of a building.
2. To establish the potential difficulties in obtaining reliable data on life costs for an individual building.
3. To gain an understanding of, and develop a methodology for measuring and analyzing, the relationship of life costs of a building to its original construction cost.

Phase B

To compare for two or more buildings:

1. One or more selected items of life costs, and,
2. the construction cost of those building elements which have significant effect on these life cost items

in order to establish the nature of the justification for particular building element designs.

5. Methodology

It is proposed to proceed as follows:

(a) Review of literature

Phase A

(b) Selection of building.

- (i) establish desirable characteristics of selected building
- (ii) make selection

6. Organization for Pilot Study

It is proposed to carry out this study with the following groups and personnel:

(a) Four members of OAPPPA, one of whom acts as Chairman of the Study.

(b) One representative of the C.O.U. Committee on Capital Finance.

(c) A member of the C.O.U. Secretariat, acting as Secretary of the Study.

(d) Hanscomb Roy Associates, as consultants in building costs and quantity surveying.

(e) Representative from the Ministry of Colleges and Universities.

A more detailed list of proposed responsibilities is attached.

7. Cost of Study

Travelling costs for the non-consulting members of the Task Force are borne by the Universities themselves. The costs of typing, printing and binding the report are nominal and will be paid for by C.O.U.

The only significant item of cost are the fees and expenses of the consultant. Based on a careful analysis of their role and specific responsibilities, these costs are estimated at $12,825.00,as described in the attached submission from Hanscomb Roy Associates, which this Proposal recommends be accepted.

8. Duration

It is expected that a final draft report of the study would be available for submission to the Committee on Capital Finance in the spring of 1973.

November 23, 1972.

Responsibilities

The following are suggested responsibilities for the various members of the Task Force.

Task Force Members

Review and approve objectives, methodology and schedule of study.
Review and approve final selection of buildings and cost elements.
Review and approve necessary definitions.
Organize procurement of information on University buildings.
Arrange for visits by Task Force and consultants to campuses, as necessary.
Visit each subject building at least once to survey the buildings.
Assist consultant in analyzing and understanding life costs.
Supervise work of consultants.
Provide material for final report, as discussed and agreed.
Review and approve final report.

Chairman

Coordinate activities of the Task Force.
Provide primary contact for consultants and C.O.U. representative.
Arrange for meetings and prepare agenda.
Edit final report for review and approval of Task Force.
Coordinate communications relating to the Study.
Review progress against agreed schedule and initiate corrective action, where appropriate.

Consultants

Assist Task Force in developing methodology.
Assist Task Force in selection of University and non-university buildings and life cost elements.
Prepare component descriptions related to cost elements.
Visit each subject building and discuss life cost data with University representatives.
Perform cost analysis and comparison of building cost elements and life cost elements on a maximum of four buildings and two elements.
Prepare draft summary and commentary on analysis and comparison.
Assist Task Force in preparation of report.

Representative from C.C.F.

Assist Task Force in its activities.
Liaise with C.C.F.

C.O.U. Representative

Assist Task Force in its activities.
Prepare and circulate minutes.
Arrange for clerical assistance.
Liaise with C.O.U. research staff.

BIBLIOGRAPHY

(1) Building Design Evaluation Costs in Use, by P. A. Stone published by E & F Spon Ltd., London, U.K. 1967, 207 pp.

(2) Deep or Shallow Building - A comparison of costs in use, by P. F. Bottle & L.E.S. Piper, published by Laboratories Investigation Unit, U.K. (sponsored by the Department of Education and Science and the University Grants Committee) 1970, 15 pp.

(3) Total Building Cost Appraisal, by John Southwell published by the Royal Institution of Chartered Surveyors, London, U.K. 1967, 36 pp.

(4) Ultimate Cost of Building Walls, by C. T. Grimm and J. C. Gross published by the Structural Clay Products, Washington, D.C. 1958.

(5) Design Evaluation for a Hospital Building, by P. A. Stone published by Architects' Journal Vol. 140 p.10, 1964.

(6) Cost Prediction: A Guide to Design Decisions, by P. A. Stone published by Architects' Journal Vol. 133 p.3437, 1961.

(7) Capital Cost and Cost in Use, by Study Group of N.W. London, branch of RICS, 1970.

(8) The Application of Design Evaluation Techniques, by P. A. Stone published Building 20 March 1970, 5 pp.

(9) The Economics of Relocating Partitions, by P. F. Bottle published by Building 20 November 1970, 3 pp.

(10) Economic Criteria & Building Decisions, by P. A. Stone published Building 20 February 1970, 4 pp.

(11) Building Decisions and Economic Appraisal Techniques in Practice, by M. C. Fleming, published Building 17 April 1970, 6 pp.

(12) Running Costs of Hospital Buildings, BRS Design Paper 65.

(13) The Maintenance & Running Costs of School Buildings, BRS Current Paper 72/68, 1968.

(14) The Relationship of Capital, Maintenance & Running Costs - a case study of two Crown office buildings, published by Ministry of Public Building & Works, 1970, 12 pp.

(15) Office Building Experience Exchange Report, published by National Association of Building Owners & Managers (BOMA) annually.

(16) Optimisation by Evaluation in the Appraisal of Buildings (2 parts) by T. A. Markus, published by Building, Part 1 - 21 Aug. 1970, 7 pp., Part 2 - 18 Sept. 1970.

(17) The Role of Building Performance Management & Appraisal in Design Method, by T. A. Markus, published by Architects' Journal, 20 Dec. 1967, 7 pp.

(18) The Real Cost of a Window - an exercise in cost benefit analysis in Building Design, by University of Strathsclyde, Dept. of Architecture & Building Science, report No.62, Feb. 1967.

(19) Operating Costs of Services in Office Buildings, BRS Digest 138, Feb. 1972

(20) The Decision to Build (Discounting, Cost-in-use, Investment Appraisal & Cost-benefit Analysis), published by the Ministry of Public Building & Works U.K., 1970, 21 pp.

(21) Discounted Cash Flow Technique, by M. G. Wright, published by The Building Economist (Aust.), 4 pp.

(22) Building Maintenance Conference Papers, published by the Ministry of Public Building & Works, 1969, 215 pp.

(23) Design, Maintenance & Operation, published by the Ministry of Public Building & Works, 1966, 16 pp.

(24) The Relationship between Design & Maintenance, published by the Ministry of Public Building & Works, 1970, 66 pp.

(25) Formula Approach to Plant Maintenance Budgeting in Ontario Universities, by C. William Morgan, University of Windsor, Master's Thesis 1972, 43 pp.

(26) Building Maintenance Cost Information Service, published by Royal Institution of Chartered Surveyors, London, U.K., annual subscription basis.

(27) Costs in Use - A guide to data and techniques, published by Department of Environment, London, 1972, 71 pp.

(28) Investigation of Maintenance & Energy Costs for Services in Office Buildings, BRS Current Paper 38/71.

(29) Energy Consumption & Cost in Two Large Air-conditioned Buildings, BRS Current Paper, 40/68.

(30) Financial/Engineering Analysis of Air Conditioning System for U.S. Government Constructed Buildings, by William S. Fleming, Market Development Supervisor, Owens-Corning Fiberglas, April 1972, 51 pp.

(31) Study of Health Facilities Construction Costs, sponsored by G.A.O. Part of study undertaken by Westinghouse Health Systems. Undated report, 106 pp.

(32) Thermal Design of Building Envelopes for minimum Total Cost, by G.L. Gupta and M. Anson, Build International Nov/Dec 1972, 9 pp.

(33) The Economy of Energy Conservation in Educational Facilities, a report from Educational Facilities Laboratories, 1973, 81 pp.

(34) Value in Building, by G.H. Hutton and A.D.G. Devonald, published by Applied Science Publishers Ltd, London, England, 1973, 136 pp.

(35) Here you have it: Life Cycle Costing, by Robert Ramsey and Robert Guthrie, AIA Journal July 1973, 7 pp.

(36) Obsolescence Report, General Services Building, Northern Colony and Training School; Bureau of Facilities Management, State of Wisconsin, July 1973, 14 pp.

(37) Building Blocks Volume 4, Report of the Task Force on Building Costs (a comparison of the costs of building elements related to design requirements for selected university and non-university buildings in Ontario), Council of Ontario Universities, Toronto, July 1972, 85 pp.

(38) Collected Papers, National Association of Physical Plant Administrators, Regional Papers 1968

APPENDIX 3

REQUESTS FOR DATA ON ALTERATIONS EXPENDITURES

The responses to these requests are on file at the Council of Ontario Universities and the Ministry of Colleges and Universities, Capital Support Branch

UNIVERSITY OF GUELPH · GUELPH · ONTARIO · CANADA AREA CODE 519 · 824-4120

Postal Code: NIG 2W1

December 28, 1972.

Re: Cyclical Renewal

Dear

Initial responses to my letter of November 27, 1972 have included queries from several universities concerning the inclusion or exclusion of data on alterations projects funded from operating budgets. Your Task Force has discussed this matter and it has been agreed that such projects should be included, but shown separately, in the information previously requested on the costs of alterations projects.

Specifically, the Task Force requests your further assistance as follows:

1) For as many of the previous years as possible, up to five, provide a total dollar amount for each year, covering the total cost of alterations funded from operating budgets or sources other than M.C.U. capital grants,as defined under components 2 and 3 of cyclical renewal in the material attached to the November 27 letter. If necessary, eliminate on an estimated basis, any significant amounts included for renovation components of the projects. Do not include projects which were entirely renovations (component 1 of cyclical renewal).

2) For each year, provide a list of all projects included in the annual amount, showing for each project:

   - a code number or abbreviated name, of no current significance to the Task Force but which would enable the Task Force to identify to you certain projects for detailed analysis at a later time.

   - the dollar amount of the alterations work.

.... 2

3) There are no minimum or maximum values to projects to be listed.

It would be appreciated if this information could be submitted to Mr. John Long at C.O.U. not later than January 21, 1973. The reason for this timing is that we are looking for information which might reinforce a claim for more cyclical renewal funds, to be made by the Join Sub-Committee on Capital Finance to the Government, prior to the finalizing of decisions relating to the 1973-74 financial year.

Your information will again be most helpful.

Yours very truly,

H. Graupner, P.Eng,
Assistant Director of Physical
Resources, Planning.

HG:dh

UNIVERSITY OF GUELPH · GUELPH · ONTARIO · CANADA
N1G 2W1
AREA CODE 519 · 824-4120

November 27, 1972

Re: Cyclical Renewal

Dear Mr.

As Chairman of the joint C.O.U./O.A.P.P.P.A. Task Force on Cyclical Renewal and Life Costs, I am writing to request your assistance in a study of cyclical renewal. In view of the freeze on new construction at Universities, which has just been announced by the Minister of Colleges and Universities, the Task Force feels that it is more important than ever before that universities should be able to make "more intensive use of existing facilities" (the Minister's words), by renovating or altering buildings, where appropriate.

Among the objectives of this Task Force are the preparation of a definition for the various components of cyclical renewal and the establishment of a formula for an allowance to adequately cover their cost. To this end, preliminary statements and methodologies have been prepared and these are being distributed to each university with this letter. The enclosures consist of:

1. A statement entitled "Cyclical Renewal", dated November 22, 1972 (page 1-5).

2. Descriptive material showing proposed methodologies for assessing costs of components one and two of the suggested definition for cyclical renewal (pages 6-28).

Your assistance as follows would be appreciated by the Task Force:

1. Submit any comments of a general nature on the attached documents, particularly on the proposed methodologies. Regarding definitions, you will see that the definition now proposed is similar to the one proposed last year by Mr. Lobban. Comments on that were mailed by Mr. Lobban to all universities and discussed at a special

Continued

November 27, 1972

meeting at the Skyline Hotel, Toronto, on January 13, 1972.

2. Provide the data for your university, equivalent to tables 3, 4, 5 (pages 17, 18, 19). These tables essentially relate the size of the university (in net assignable square feet) in a given year, to the total cost of alteration projects during that year for each year of as long a period as can be obtained from your records. Do not include purely renovation projects, i.e. those which do not include any work on alteration or remodelling for changes in occupancy, use, methodology or technology.

For each project included in your table 3, please complete a copy of the balnk form on page 28. An example of the use of this form, is on page 22.

Your comments and data should be sent to:

Mr. John Long
Secretary
Task Force on Cyclical Renewal and Life Costs
Council of Ontario Universities
102 Bloor Street West
TORONTO 181, Ontario

by January 2, 1972.

Your assistance will be very much appreciated.

Yours very truly,

H. Graupner, P.Eng.
Assistant Director of Physical Resources
Planning

HG:mw

enc

CYCLICAL RENEWAL

The introduction of the Interim Capital Formula in 1969 came at the end of a decade in which enrolments had been rising steadily and rapidly. The main thrust of the formula was therefore directed toward providing additional new space to accommodate increased numbers of students and toward meeting concomitant requirements for site acquisition and development.

In 1970 and 1971 the Interim Formula was revised to take some account of the age and quality of buildings - the age-quality allowance - and the need to remodel and renovate buildings - the cyclical renewal allowance. These were important innovations but in a time of increasing enrolment they were regarded as secondary features of the formula, somewhat preliminary in nature and based on rather gross assumptions.

As enrolment levels off these secondary features become all important. The cyclical renewal allowance provides the only continuing source of capital funds for keeping the physical plant in good repair and for remodelling to suit changes in use made necessary by enrolment shifts and changing methodology and technology.

This paper will raise questions about the purpose, definition and scope of cyclical renewal, indicate the urgent need for further study, outline possible methodologies for dealing with some components of cyclical renewal and suggest some matters requiring prompt decisions. It is intended to serve also as an introduction to the detailed description of a methodology developed at Carleton University for estimating the funds needed to handle the first two components of cyclical renewal in the list which follows. In addition, it will introduce the request for comment and the volunteering of relevant data going out to the Ontario universities and MCU.

Definition and Scope

A precise definition of the cost elements intended to be covered by the cyclical renewal allowance in the present Interim Formula seems not to have been made. Various suggestions have been offered as to the coverage of cyclical renewal including some or all of the following:

1) major repairs to and replacement of building subsystems or elements such as interior finishes, roof, lighting, etc. made necessary by normal use and deterioration,

2) alterations or remodelling made necessary by changes in occupancy, use, methodology or technology,

3) alterations or remodelling made necessary by changing code requirements such as those covering fire and animal care,

4) replacement of major non-building equipment such as audio-visual equipment and instructional equipment in scientific and other special purpose laboratories or spaces,

5) replacement of furniture,

6) replacement of outmoded buildings.

In discussions to date some have favoured a narrow interpretation of cyclical renewal, restricted to the first element mentioned above, and the addition of new allowances to the capital formula to cover the remaining cost elements. Others have argued that cyclical renewal should be given the broadest interpretation possible so as to keep the number of allowances in the capital formula to a minimum and thereby maintain the maximum flexibility for the recipients of the funds - the universities.

The Committee on Capital Financing asked a small group of OAPPPA members to consider problems related to cyclical renewal and to come forward with proposals for studying them. This group met on October 24th and concluded that the scope of cyclical renewal should be specified as set out below.

The cyclical renewal allowance should provide funds adequate to cover all costs related to the provision of physical facilities except the following:

(a) new facilities made necessary by increased enrolment, i.e. overall university enrolment,

(b) site acquisition and other costs presently covered by the non-formula portion of the Interim Formula,

(c) normal maintenance including minor repairs. Preliminary attempts have already been made by OAPPPA to define the scope of normal maintenance.

Each of the possible components of cyclical renewal listed on page 2 will now be considered in turn.

1) Major Repairs to and Replacement of Building Elements or Subsystems.

A methodology for assessing the funds required to meet the needs arising from this component of cyclical renewal follows logically from the procedure used in the COU cost study and described in Building Blocks, Volume 4. In brief it goes somewhat as follows:

(a) an analysis can be made of the average costs, expressed as percentages of the total project costs, for the major elements and sub-elements (substructure, horizontal structural elements, cladding, interior vertical elements, etc.) of buildings.

(b) each element and subelement can be examined to determine what percentage of the element will need to be replaced during the economic life of a building and at what age that percentage will be replaced. (Studies of life costs would be most helpful in aiding this determination).

(c) from (a) and (b) above a profile of major repair and replacement costs can be built up still expressing all costs in terms of percentages of project cost;

(d) from the profile obtained in (c) average annual percentage costs over each five or ten year interval of building life can be obtained;

(e) the average annual percentage costs can be converted to cost per year per NASF using an appropriate unit cost factor (currently $55 per NASF is used);

(f) finally, the needs of any one university in any one year can be assessed from the known NASF and age of each building on the campus of that university.

2) Alterations and Remodelling Due to Changes in Occupancy, Use, Methodology or Technology.

An assessment of the funds needed for this can be made on the basis of historical data obtained from the files on projects submitted to MCU for approval. It would be necessary to estimate the proportions of each project properly belonging within this component. The amount spent each year could then be related to the total space available on campus that year and a cost per year per NASF could be derived. Finally, the figures for each year could be averaged to obtain an overall average.

3) Alterations or Remodelling Due to Changes in Fire, Animal Care or Other Codes.

The funds needed for this purpose are quite unpredictable. The most reasonable approach would be to apply for funds on a project-by-project basis, each application being supported by a statement from the appropriate official in the agency having jurisdiction.

4) Replacement of Major Non-Building Equipment

The problems arising under this category are fairly obvious and relate primarily to assessing the economic life of equipment of various kinds. The current unit cost allowance of $55 is expected to cover furniture and equipment, indicating that these are to be regarded as capital costs, hence it would seem logical to derive an allowance for this component of cyclical renewal.

5) Replacement of Furniture

This component could be treated as an element of the building and included in the methodology for component number 1. Furniture constitutes a considerable percentage of total project cost and because of its relatively short life it is likely to be a significant component of cyclical renewal.

6) Replacement of Outmoded Buildings.

When a building reaches the end of its useful life and demolition and replacement are indicated it would seem logical that an application should be made to MCU for a reduction in allocation inventory equal to the area of the building to be demolished. This would increase entitlement by the building area times the appropriate dollar allowance. A similar procedure might be used where the structure of a building is to be retained but the interior must be gutted and completely rebuilt resulting in costs almost equal to those of demolition and replacement.

Concluding Remarks

The current method of generating cyclical renewal is based on a percentage of the allocation inventory plus a percentage of the cumulative cash flow. This approximates an allowance of 55¢ per NASF per year at the present rate of 1 percent allowance and a unit cost of $55 per NASF. It would be logical that a revised allowance should relate back to the allocation inventory and the cumulative cash flow. This should be kept in mind in developing any new methodology.

Several detailed but quick studies have been done by individual universities to derive a reasonable figure for cyclical renewal. The findings must be regarded as preliminary and approximate only, but the indications are that the present allowance of 1 percent is not adequate to cover even the first two components of cyclical renewal listed in this paper let alone most or all of them.

In view of the current uncertainties relating to cyclical renewal and the difficult financial situation of a number of universities it would seem that early decisions are required with respect to the following:

1) the scope of cyclical renewal and the precise definition of the components to be included,

2) the initiation of further studies aimed at developing methodologies for the assessment of the funds needed for each of the components of cyclical renewal,

3) a device for making funds for cyclical renewal available to universities currently in a negative entitlement situation and likely to remain in such a situation for some time into the future,

4) an increase from the current one percent allowance for cyclical renewal.

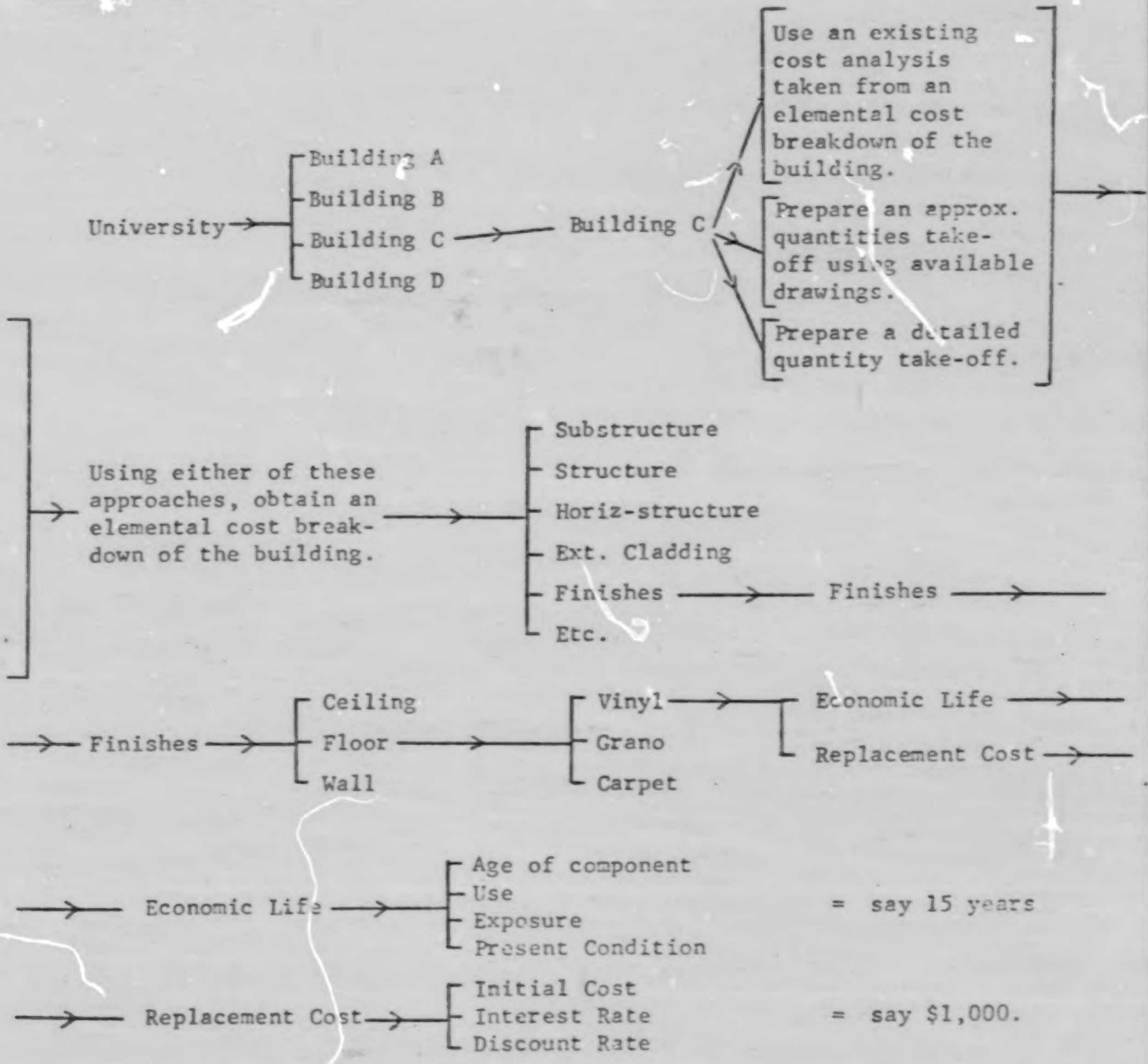
November 22, 1972.

Methodology for Component 1

This methodology provides a means of assessing the funds required annually for major repairs to and the replacement of building sub-systems or elements such as interior finishes, roofs, lighting, etc. made necessary by normal use and deterioration.

Using the same methodology, there are two approaches available, either the ideal approach which demands a study at a high level of detail, or the proposed approach which has been developed because of the time available.

The Ideal Approach


University
Building A
Building B
Building C
Building D
Building C

Use an existing cost analysis taken from an elemental cost breakdown of the building.

Prepare an approx. quantities take-off using available drawings.

Prepare a detailed quantity take-off.

Using either of these approaches, obtain an elemental cost breakdown of the building.

Substructure
Structure
Horiz-structure
Ext. Cladding
Finishes
Etc.
Finishes
Finishes
Ceiling
Floor
Wall
Vinyl
Grano
Carpet
Economic Life
Replacement Cost
Economic Life
Age of component
Use
Exposure
Present Condition
= say 15 years
Replacement Cost
Initial Cost
Interest Rate
Discount Rate
= say $1,000.

TABLE ONE

ANALYSIS OF ELEMENTAL PERCENTAGES FOR THE SIX UNIVERSITY BUILDINGS

Element/Sub Element	C.S.C.	Law Bldg.	Guelph	York	Wat M&C	Wat Eng.	Tot.	÷	Univ. Ave.	Non Univ. Ave.
Indirect and General	9.0	9.1	8.5	8.5	9.1	7.5	51.7	6	8.6	7.0
Substructure	3.0	4.3	3.5	1.2	3.3	4.0	19.3	6	3.2	1.8
Normal Fdns.	1.0	1.1	2.0	0.3	2.3	3.6	10.3	6	1.7	
Basement Exc.	0.3	0.6	1.5	0.9	0.7	0.4	4.4	6	0.7	
Special Fdns.	1.7	2.6	-	-	0.3	-	4.6	6	0.8	
Horizontal Struct. Element	11.5	21.6	13.9	13.7	17.5	16.3	94.5	6	15.8	15.2
Slabs on grade	0.7	1.3	1.6	0.9	0.6	1.3	6.4	6	1.1	
Floor & roof Constr.	9.6	17.5	10.9	10.8	15.7	13.1	77.6	6	12.9	
Roof finish	1.2	2.8	1.4	2.0	1.2	1.9	10.5	6	1.8	
Exterior Cladding	17.8	12.0	9.4	10.8	12.8	13.3	76.1	6	12.7	12.3
Walls below gd.	1.3	0.8	2.1	1.9	0.8	0.5	7.4	6	1.3	
Walls above gd.	12.1	5.3	5.1	4.4	9.1	8.6	44.6	6	7.4	
Windows	4.0	5.2	1.4	3.6	1.7	3.5	19.4	6	3.2	
Ext. doors	0.3	0.3	0.5	0.2	0.3	0.1	1.7	6	0.3	
Projns. balcs.	0.1	0.4	0.3	0.7	0.9	0.4	2.8	6	0.5	
Interior Vert. Elmts	6.8	7.0	4.3	7.9	8.6	7.1	41.7	6	7.0	5.5
Partitions	4.7	4.8	3.1	6.2	6.2	5.6	30.6	6	5.1	
Folding Ptns.	0.4	1.0	0.2	0.1	0.2	0.2	2.1	6	0.4	
Doors	1.7	1.2	1.0	1.6	2.2	1.3	9.0	6	1.5	
Multi-Storey Elmts.	4.2	2.9	1.6	2.3	3.1	1.6	15.7	6	2.6	4.6
Stairs	2.3	1.8	0.3	0.6	1.2	0.6	6.8	6	1.1	
Catwalks	-	-	0.1	0.1	0.1	0.2	0.5	6	0.1	
Elevator Hoists	1.9	1.1	1.2	1.6	1.8	0.8	8.4	6	1.4	
Escalators	-	-	-	-	-	-	-	-	-	

Element/Sub Element	C.S.C.	Law Bldg.	Guelph	York	Wat M&C	Wat Eng.	Tot.	÷	Univ. Ave.	Non Univ Ave.
Interior Finishes	9.3	9.8	4.9	4.2	7.3	5.3	40.8	6	6.8	8.9
Floor finishes	3.6	3.7	1.6	1.2	2.8	2.3	15.2	6	2.5	
Ceiling finishes	3.6	3.4	1.9	1.7	2.5	2.2	15.3	6	2.5	
Wall finishes	2.1	2.7	1.3	1.2	2.0	0.8	10.1	6	1.7	
Special finishes	-	-	0.1	0.1	-	-	0.2	6	0.1	
Fittgs. Fixt. Equip.	3.0	2.8	7.8	12.3	3.2	8.2	37.3	6	6.2	3.8
Non-Instruction	2.6	1.3	0.3	1.7	2.0	2.4	10.3	6	1.7	
Instructional	0.4	1.5	7.5	10.6	1.2	5.8	27.0	6	4.5	
Cash Allowances	2.6	1.6	0.9	1.8	2.5	1.8	11.2	6	1.9	0.9
Hardware	2.0	1.3	0.8	1.6	2.3	1.5	9.5	6	1.6	
Testing & Inspection	0.6	0.3	0.1	0.2	0.2	0.3	1.7	6	0.3	
Plumbing & Drains	5.7	2.6	6.2	6.1	3.8	5.0	29.4	6	4.9	6.0
Roughing-In	2.7	2.0	1.5	1.4	2.3	1.5	11.4	6	1.9	
Roughing	1.1	-	0.9	1.2	-	0.5	3.7	6	0.6	
Plumbing Fixt.	1.0	0.5	0.3	0.2	0.8	0.3	3.1	6	0.5	
Plumbing Fixt.	0.4	-	0.1	0.1	-	0.1	0.7	6	0.1	
Fire Protection	0.5	0.1	0.4	0.7	0.7	0.4	2.8	6	0.5	
Special Serv.	-	-	3.0	2.5	-	2.1	7.6	6	1.3	
Heating, Vent. Air Cond.	14.6	16.2	23.2	18.2	15.8	16.7	104.7	6	17.3	20.1
H.V.A.C.	14.6	16.2	14.5	13.8	14.0	14.5	87.6	6	14.5	
Special Systems	-	-	8.7	4.4	1.8	2.2	17.1	6	2.8	
Electrical	12.5	10.1	15.8	13.2	13.0	13.2	77.8	6	13.0	13.9
Transformer & Wiring	1.6	2.8	6.2	1.7	2.9	1.1	16.3	6	2.7	
Lighting & Wiring	4.8	4.8	5.7	5.7	6.3	5.0	32.3	6	5.4	
Underfloor Duct System	-	-	0.5	0.6	1.6	0.6	3.3	6	0.6	
Special Systems	6.1	2.5	3.4	5.2	2.2	6.5	25.9	6	4.3	

The Proposed Approach

The data base for this approach will be the Building Blocks Volume Four.

Refer to Table One

This table is an analysis of the elemental percentages for the six university buildings. The analysis deals only with construction cost and is not a breakdown of the total project cost.

For our purposes the important column is the one headed - University Average. These are the figures which have been used for further analysis. The column headed - Non-University Average, has been shown for comparision purposes only. Eventually the available information on the non-university buildings may be added to the data base and incorporated in the analysis.

Refer to Table Two

As explained under the heading of "The Ideal Approach", the final and most crucial step is the assessment of the economic life and the replacement cost of each component of the building. Studying a building to this level of detail would be a lengthy process.

Our proposed approach is much simpler and gives results based on reliable data. Rather than examine the buildings at the component level, we shall only examine at the sub-element level.

For each sub-element one must judge:

a) The total percentage of the sub-element which will be replaced during the economic life of the building and

b) At what time and in what proportions during the life of the building that percentage will be replaced.

In this particular paper, these two critical judgements have been based on a limited experience of building material and building element life expectancies. However, in the case of certain elements such as the H.V.A.C. and the electrical other member of the construction department at Carleton were consulted.

One way of improving the input at this stage of the methodology would be to ask each University to complete table two ignoring the actual assessment shown and substituting their own evaluation of the economic life and replacement costs of the sub-elements.

It should be noted that percentages for 1) indirect and general expenses 2) professional fees and 3) contingencies have been added at the end of table two. Please note also that the cost of furniture and equipment has not been included in the analysis.

Table Two

ASSESSMENT OF THE REGULARITY AND THE AMOUNT REPLACED FOR EACH ELEMENT DURING THE ECONOMIC LIFE OF THE BUILDING

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Indirect and General	8.6	(these costs have been added at the end of this table)								
Substructure										
Normal Foundation	1.7			1% 0.17				1%	0.170	
Basement Excavation	0.7		2% 0.014		2% 0.014			4%	0.028	
Special Foundations	0.8		2% 0.016		2% 0.016			4%	0.032	
Sub-Total	3.2		0.030	0.170	0.030				0.230	0.310
Horizontal Structure										
Slabs on Grade	1.1			1% 0.011				1%	0.011	
Floor & Roof Constr.	12.9	2% 0.258	2% 0.258	2% 0.258	2% 0.258	2% 0.258		10%	1.290	
Roof Finish	1.8	50% 0.900	50% 0.900	50% 0.900	50% 0.900	50% 0.900			4.500	
Sub-Total	15.8	1.158	1.158	1.158	1.158	1.158			5.801	7.820

Table Two

(1) Group Element and Element	(2) Avge. Elmt. %age	(3) At 10	At 20	At 30	At 40	At 50	At 60	(4) %age of Element Replaced	(5) % of Total Replaced	(6) Sub-Total % as % of Total % Repl.
Exterior Cladding										
Walls below Grade	1.3			2% 0.026				2%	0.026	
Walls above Grade	7.4	2% 0.148	3% 0.222	4% 0.296	5% 0.370	6% 0.444		20%	1.480	
Windows	3.2		20% 0.64	20% 0.64	30% 0.96			70%	2.240	
Exterior Doors	0.3		20% 0.06	20% 0.06	20% 0.06			60%	0.180	
Projection & Bale.	0.5	1% 0.005	2% 0.010	3% 0.015	4% 0.020			10%	0.050	
Sub-Total	12.7	0.153	0.932	1.037	1.410	0.444			3.976	5.360
Fittings Fixt. and Equipment										
Non-Instructional	1.7	10 0.17	20 0.34	20 0.34	40 0.51			80	1.360	
Instructional	4.5	10 0.45	20 0.90	20 0.90	30 1.35			80	3.600	
Sub-Total	6.2	0.62	1.24	1.24	1.86				4.960	6.680
Cash Allowance										
Hardware	1.6	10 0.16	20 0.32	30 0.48	30 0.48			90	1.440	
Testing and Inspect.	0.3									
Sub-Total	1.9	0.16	0.32	0.48	0.48				1.440	1.940

Table Two

(1) Group Element and Element	(2) Avge. Elmt. %age	(3) At 10	At 20	At 30	At 40	At 50	At 60	(4) %age of Element Replaced	(5) % of Total Replaced	(6) Sub-Total % as % of Total % Repl.
Interior Vertical Elements										
Partitions	5.1	10 0.510	10 0.510	20 0.020	30 1.530			70	3.570	
Folding Partitions	0.4	5 0.020	10 0.04	15 0.060	20 0.080			50	0.200	
Doors	1.5	5 0.075	5 0.075	10 0.150	10 0.150	20 0.300		50	0.750	
Sub-Total	7.0	0.605	0.625	1.230	1.760	0.300			4.520	6.090
Multi-Storey Elements										
Stairs	1.1	2 0.02	2 0.02	2 0.02	2 0.02	2 0.02		10	0.110	
Catwalks	0.1									
Elevators and Hoists	1.4		30 0.42		60 0.84			90	1.260	
Escalators	-									
Sub-Total	2.6	0.020	0.440	0.020	0.860	0.020			1.370	1.840
Interior Finishes										
Floor Finishes	2.5	50 1.25	50 1.25	50 1.25	50 1.25	50 1.25		250	6.250	
Ceiling Finishes	2.5	50 1.25	50 1.25	50 1.25	50 1.25	50 1.25		250	6.250	
Wall Finishes	1.7	25 0.425	25 0.425	25 0.425	25 0.425	25 0.425		125	2.125	
Special Finishes	0.1	25 0.025	25 0.025	25 0.025	25 0.025	25 0.025		125	0.125	
Sub-Total	6.8	2.950	2.950	2.950	2.950	2.950			14.750	19.800

Table Two

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Plumbing and Drains										
Roughing-In (O)	1.9	10 0.19	20 0.38	20 0.38	30 0.57			80	1.520	
Roughing-In (S)	0.6	10 0.06	20 0.12	20 0.12	30 0.18			80	0.480	
Plumbing Fixt. (O)	0.5	10 0.05	50 0.25	50 0.25	50 0.25	40 0.20		200	1.000	
Plumbing Fixt. (S)	0.1	10 0.01	50 0.05	50 0.05	50 0.05	40 0.04		200	0.200	
Fire Protection	0.5		100 0.50		100 0.50			200	1.00	
Special Services	1.3		100 1.30		100 1.30			200	2.600	
Sub-Total	4.9	0.310	2.600	0.800	2.850	0.240			6.800	9.170
Heating Vent. Air Conditioning										
H.V.A.C.	14.5		20 2.90	35 5.075	45 6.525			100	14.500	
Special Systems	2.8		20 0.56	35 0.980	45 1.260			100	2.800	
Sub-Total	17.3		3.46	6.055	7.785				17.300	23.490

Table Two

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Electrical										
Transformers	2.7		20 0.54	35 0.945	45 1.215			100	2.700	
Lighting & Wiring	5.4		20 1.08	35 1.89	45 2.43			100	5.400	
Underfloor Ducts	0.6		20 0.12	35 0.21	45 0.27			100	0.600	
Special Systems	4.3		20 0.86	35 0.505	45 1.935			100	4.300	
Sub-Total	13.0		2.600	4.550	5.850				13.000	17.500
Total	100%	5.976	16.355	19.701	26.993	5.112	0		74.147	100%
Indirect and General	8.6	0.514	1.406	1.694	2.321	0.441	0		6.376	
Professional Fees	10.0	0.598	1.636	1.970	2.699	0.512	0		7.415	
Contingencies	3.0	0.179	0.491	0.591	0.809	0.154	0		2.224	
Total percentage (excluding furniture and equipment)		7.267	19.888	23.956	32.822	6.219	0		90.162	

From Table Two one could draw several conclusions

a) During the sixty year life of the building approximately 90% of the construction cost will be spent on major renovation projects.

b) For the periods shown below the expenditure will be as follows:

0 - 10	years	7.267%	of	construction	cost
10 - 20	"	19.888%	"	"	"
20 - 30	"	23.956%	"	"	"
30 - 40	"	32.822%	"	"	"
40 - 50	"	6.219%	"	"	"
50 - 60	"	0%	"	"	"

c) Of the total to be spent on major renovations;

19.8% will be spent on the Interior Finishes

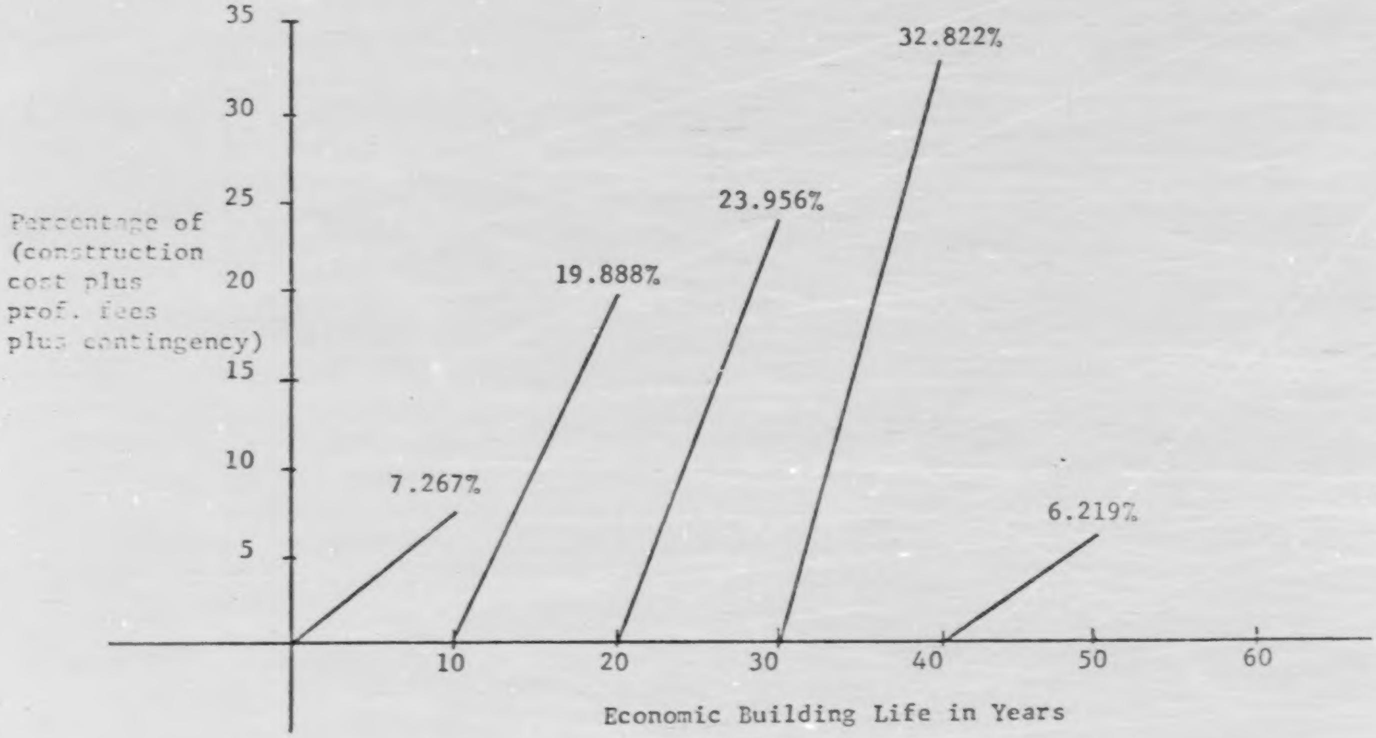
23.5% " " " " " H.V.A.C.

17.5% " " " " " Electrical

This would suggest that in any future study of building life costs one should concentrate on the three elements above.

How can the results from Table Two be applied to any University to obtain a yearly amount for the Major Renovation Component of Cyclical Renewal.

The total percentages shown at the end of Table Two can be represented graphically.



For our purposes, the economic life of a building has been divided into six equal ten year spans, i.e., 0 - 10, 10 - 20, etc. From the graph we predict that 7.267% of the total cost will be needed for major renovations during the first ten years. Similarly 19.888% will be needed during the period ten to twenty years.

As an average, during the first ten years of life, 7.267 ÷ 10 = 0.727% will be needed annually. A more accurate assessment of the yearly amounts required could be obtained by reducing the range from ten to five or even one year. This, however, would necessitate a more refined assessment at the cost analysis level.

Presently the cyclical renewal amount is expressed as a percentage of the allocation inventory plus a percentage of the cumulative cash flow. This equates to 55¢ per N.A.S.F. It would be useful if our methodology could present its results in the same terms.

Refer to the following Table

Yearly Range	% of Total Cost Replaced	Average Yearly Percentage	Times $50	Divided by 55
0 - 10	7.267	0.727	36¢/NASF	0.65%
10 - 20	19.888	1.989	99¢/NASF	1.80%
20 - 30	23.956	2.396	120¢/NASF	2.18%
30 - 40	32.822	3.282	164¢/NASF	2.98%
40 - 50	6.219	0.622	31¢/NASF	0.56%

The dollar figure used, i.e. $50. takes account of the fact that furniture and equipment have not been included under the assessment for the component 1 of cyclical renewal.

The column entitled "divided by 55" gives percentages which are directly comparable with the present 1% being used in the entitlement calculations.

However, remember that only the future costs of major renovations have this far been assessed and there are still five other components of cyclical renewal to be examined.

Unfortunately, the results of our analysis give varying percentages depending on the age of the building. However, using the variable percentage does give a more realistic assessment of the funds required at a particular time during the life of a building. It is possible to obtain a fixed percentage by dividing the total percentage by the 60 year life.

i.e. 90.16 ÷ 60 = 1.50%

referring to the last table, this percentage would be under the heading of the "average yearly percentage".

Given any University, how would the funds for major renovations be calculated using either a) a variable percentage or b) a fixed percentage.

The current method of calculation used by the Province takes no account of the age of buildings.

a) a variable percentage

Building	Age	N.A.S.F.		Variable Major Renovation Percentage		Times $55		Funds for Major Renovs.
A	18	20,000	×	1.80	×	55	=	19,800
B	33	60,000	×	2.98	×	55	=	98,340
C	5	15,000	×	0.65	×	55	=	5,363
D	40	70,000	×	0.56	×	55	=	21,560
		165,000						145,063

The percentages used under "variable major renovation percentage" were taken from the previous table and are the ones comparable with the 1% presently being used by the Ministry.

b) a fixed percentage

average yearly fixed percentage	= $\frac{90.16}{60}$ =	1.50%
Times dollar allowance per N.A.S.F., i.e. $50.	=	× 50
Allowance per N.A.S.F. for major renovations.	=	75¢
Divided by 55 to obtain		÷ 55
a percentage directly comparable with the 1% being used by the Ministry.	=	1.36%

Building	Age	N.A.S.F.	All. Inv.		Fxd. Major Renov. %		Times $55		Funds for Major Renovs.
A	18	20,000]	165,000	×	1.36	×	55	=	123,420
B	33	60,000]							
C	5	15,000]							
D	40	70,000]							

If the second phase of the C.O.U. cost study is continued, its findings would no doubt provide invaluable information on both the economic life and the replacement costs of building components.

Methodology for Component 2

This methodology provides a means of assessing the funds required annually for alterations or remodelling made necessary by changes in occupancy, use, methodology or technology.

A realistic study is difficult especially in the time available. However, a crude assessment can be made based on the available historical data.

Our data base will be the information in our capital project files. The historical base could be extended to include the major alterations in other Ontario Universities.

Refer to Table Three

This table lists the alteration projects which form our data base. The right hand column shows the yearly amounts spent since 1965 on alteration projects. These amounts could be related to the net assignable area of the University.

Refer to Table Four

The table shows how the University has increased in size since 1959.

Refer to Table Five

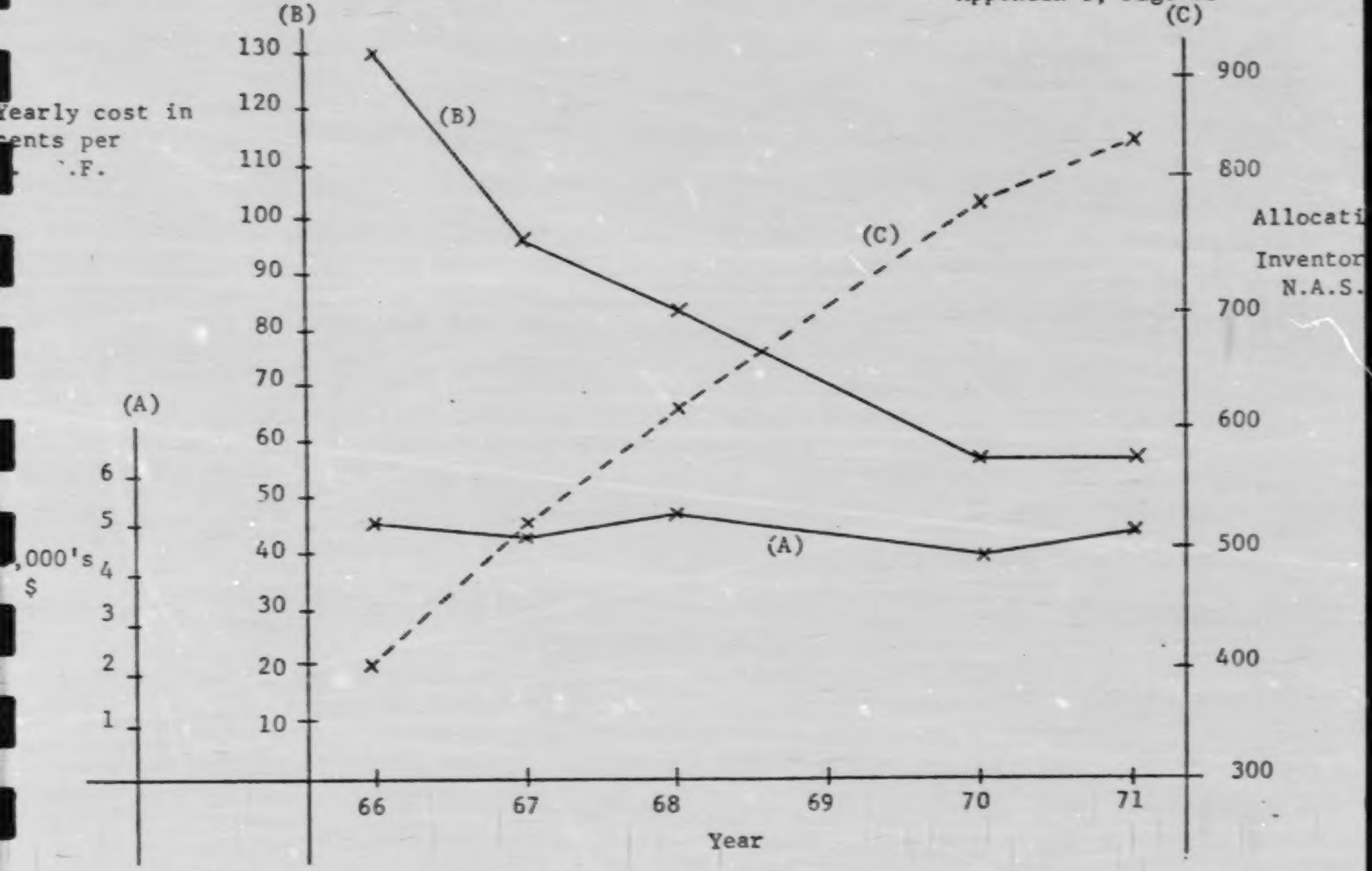
This table utilizes the information in the right hand columns of tables three and four. The cost of alterations in 1966 has been related to the size of the University in 1965, etc. After division the figures in column three of table five indicate the yearly cost per net assignable square foot.

It would appear from the table that 1966, 1967, 1968, 1970 and 1971 are typical years. The reasons for the unusual amounts in 1964, 1969 and 1972 should be studied in more depth. For our purposes only the "typical" years will be used for further analysis.

Table Five

	① Yearly Cost of Altns in Year (x)		2) Alloc. Inventory in Year (x-1)		3) Yearly Cost / N.A.S.F.	[illegible] % of Alloc. Invent. × $55.
1965	1,088,933	÷	325,917	=	3.26	Unusual
1966	509,751	÷	394,401	=	1.29	2.34
1967	486,254	÷	500,775	=	0.97	1.76
1968	521,165	÷	621,589	=	0.84	1.53
1969	Nil					Unusual
1970	453,472	÷	793,483	=	0.57	1.04
1971	491,350	÷	848,391	=	0.57	1.04
1972	114,616	÷	931,784	=	0.12	Unusual

The results from this table can be represented graphically.



To read the graph, line 'a' should be read with the vertical axis 'a', line 'b' with the vertical axis 'b', etc.

Conclusions from the Graph

1) The amount spent per net assignable square foot will obviously decrease as the universities size increases, providing the total amount spent each year remains constant.

2) The right hand column of Table Five attempts to relate the cost of alterations to a percentage of the allocation inventory times $55. The percentage varies suggesting that the cost of alterations should not be related to the allocation inventory.

3) During the "typical years" the total amount spent on alterations is constantly around the $500,000. figure. During the period 1965 to 1971 the size of the university almost trebled. This would also suggest that the yearly amounts spent on major alteration projects is not related to the size of the University.

TABLE THREE

CARLETON UNIVERSITY
MAJOR ALTERATION AND RENOVATION PROJECTS

The projects listed below are in chronological order.

Project Number	Name of Project	Total Project Cost	Year of Alteration	Yearly Cost
CA 6	Tory Bldg. Altns.	568,925	1965	1,088,933
CA 14	Tory Bldg. Altns.	465,021	1965	
CA 21	Bldg. Altns. 1965	54,987	1965	
CA 24	Library Altns.	220,247	1966	509,751
CA 37	Bldg. Altns. 1966	289,504	1966	
CA 33	Library Altns.	101,567	1967	486,254
CA 36	Tory Bldg. Altns.	150,106	1967	
CA 27	Tory Bldg. Altns.	51,660	1967	
CA 44	Bldg. Altns. 1967	182,921	1967	
CA 42	Tory Bldg. Altns.	177,332	1968	521,165
CA 46	Steacie Altns.	66,019	1968	
CA 50	Paterson Hall Altns.	155,597	1968	
CA 54	C.J. Mackenzie Altns.	122,217	1968	
CA 60	Library Altns.	280,390	1970	453,472
CA 65	Admin. Bldg. Altns.	173,082	1970	
CA 66	Steacie Altns.	70,601	1971	491,350
CA 67	C.E. Facility Altns.	73,615	1971	
CA 68	Loeb Bldg. Altns.	84,256	1971	
CA 72	Paterson Hall Altns.	126,913	1971	
CA 76	Tory Bldg. Altns.	135,965	1971	
CA 82	C.J. Mackenzie Altns.	114,616	1972	114,616
	Total	3,665,541		3,665,541

TABLE FOUR

CARLETON UNIVERSITY

NET ASSIGNABLE SQUARE FEET CONSTRUCTED SINCE 1959

Building Name	Part Constructed	N.A.S.F.	Ready Oct.'	Yearly Total	Cum. Total
Tory Building	All but lev. 6 extn.	65,228	1959	129,148	129,148
Field House	All	4,989	1959		
MacOdrum Lib.	Levels 1 and 2	33,722	1959		
Paterson Hall	All but extn.	25,209	1959		
Tory Building	Level 6 extn.	5,280	1962	81,537	210,685
Paterson Hall	Extension	17,151	1962		
Southam Hall	Theatre + lev. 1 to 4	26,624	1962		
Commons	All	16,305	1962		
Gymnasium	Phase One	16,177	1962		
MacOdrum Lib.	Levels 3,4 & 5	52,718	1963	52,718	263,403
C.J.Mackenzie	Block A	26,432	1964	62,514	325,917
C.J.Mackenzie	Block B	26,643	1964		
Heating Plant	Phase One	9,439	1964		
Maintenance	All	15,398	1965	68,484	394,401
Steacie	All	53,086	1965		
Southam Hall	Levels 5 & 6	14,115	1966	106,374	500,775
C.J.Mackenzie	Block C	34,505	1966		
Physics	All	57,754	1966		
Loeb	All	120,814	1967	120,814	621,589
C.J.Mackenzie	Block D	27,038	1968	49,467	671,056
Heating Plant	Phase Two	5,050	1968		
Controlled E.F.	All	17,379	1968		
Gymnasium	Phase Two	10,338	1969	122,427	793,483
Administration	All	56,372	1969		
Food Service C.	All	55,717	1969		
University Centre	All	54,908	1970	54,908	848,391
Arts 1 Tower	All	83,393	1971	83,393	931,784
Totals		931,784		931,784	931,784

It should be pointed out that the Carleton data used in tables three, four and five are "unclean" in that they include costs associated with other components of cyclical renewal in addition to those for component number two, hence the figures would tend to be somewhat higher than if they were costs associated only with component number two.

No attempt has been made so far to apply a construction cost index to the data.

There are no obvious trends indicated in either table three, four or five.

As university enrolments level off and new construction ceases, one would expect the amount of alteration work to increase. The historical data as used in this exercise may give a misleading picture of the quantity of future alterations.

Carleton is a relatively young University and its historical data available on major alterations may be limited compared with other older Universities. In fact, Carleton's data may suggest conclusions that provincially may prove invalid.

However, each University could:

a) Carry out similar analysis to those shown and

b) Provide the necessary data to a central point for an overall examination of the total available data. This would provide a more meaningful data base and hopefully more realistic results.

Our examination of the historical data has been on a general level only, one could assess particular buildings and even particular alterations in further depth.

The form entitled "Outline Description of the Scope and the Cost of Major Alteration Projects" is an attempt to collect detailed information in a standard format, which could provide a much wider base for further analysis. The form is basically straightforward. One section may need further explanation. Alteration/Renovation Breakdown.

Each of the projects listed on table three contain sections of renovation work. To increase the validity of any study on the cost of alterations an estimate must be made of the percentage of renovation work within each major alteration project.

Attached to this paper is a completed example of the major alteration information form.

Carleton University

OUTLINE DESCRIPTION OF THE SCOPE AND THE COST OF MAJOR ALTERATION PROJECTS

PROJECT NUMBER	PROJECT NAME	YEAR OF ALTERATION	TOTAL PROJECT COST
CA 14	TORY BLDG. ALTERATION	1965	465,021

SCOPE OF THE PROJECT

The Chemistry Department moved to its new building. The vacated space must be altered to meet the requirements of the Geology and Biology Departments. Work includes moving partitions replacement of deteriorated ceilings, the changing of the mechanical system to provide special temperature and humidity control, the provision of chilled water fan coil units, changes to the plumbing and the installation of the necessary furniture.

COST BREAKDOWN

	$	%	%	$/NASF	% ALTN/RENOV.
Architectural	106,486	22.89	25.91	6.47	
Built-in Furniture	83,353	17.92	20.28	5.07	
Built-in Equipment	26,708	5.74	6.50	1.62	
Allowances	7,005	1.51	1.71	0.43	
Mechanical	136,394	29.33	33.19	8.29	
Electrical	50,998	10.96	12.41	3.10	
Other	-	-	-	-	
- Net Building Cost	410,944	88.37	100.00	24.98	
Professional Fees	26,924	5.79		1.64	
Contingency	3,832	0.82		0.23	
Furniture	11,334	2.44		0.69	
Equipment	11,987	2.58		0.73	
- Total Project Cost	465,021	100.00		28.27	

N.A.S.F. Area Altered or Renovated = 16,452

Request for Information

Rather than attach a lengthy questionnaire, each University is requested to complete the following tables and carry out the following exercises.

a) Table Two

A "blank" copy of Table Two is attached. The critical input for the methodology for Component One of cyclical renewal is the assessment of the economic life and replacement cost of the building sub-elements. Please complete Table Two with your own evaluation of these factors. Using the results of your own evaluation carry out the exercises as shown within this paper.

b) Complete a Table Three.

c) Complete a Table Four.

d) Using the information from the completed tables three and four, complete a table five and associated graph.

e) For each of the projects listed under table three complete an individual project report on the standard format enclosed. It is most important that when completing this form, only meaningfull information is provided. Do not complete each part of the form for the sake of completing the form. Incompleted forms with meaningful information will still be most useful.

f) The methods of analysis used in this paper are obviously not the only means of examining the available information on alteration and renovation projects. They are merely a suggested method of procedure. Each University may well have carried out their own individual analysis. If so, firstly the results and secondly the methodology used should be communicated along with the other information requested.

g) Naturally any comments, questions and criticism on the subject of cyclical renewal and this paper would be welcomed.

As you are well aware, both the availability of and the percentage being used to generate cyclical renewal funds are crucial questions currently facing most of the Ontario Universities. Consequently, we would appreciate your early attention to this request for information.

TABLE TWO

ASSESSMENT OF THE REGULARITY AND THE AMOUNT REPLACED FOR EACH ELEMENT DURING FIRST FIFTY YEARS OF A NEW BUILDING

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Indirect and General	8.6									
Substructure										
Normal Foundation	1.7									
Basement Excavation	0.7									
Special Foundations	0.8									
Sub-Total	3.2									
Horizontal Structure										
Slabs on Grade	1.1									
Floor & Roof Constr.	12.9									
Roof Finish	1.8									
Sub-Total	15.8									

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Exterior Cladding										
Walls below Grade	1.3									
Walls above Grade	7.4									
Windows	3.2									
Exterior Doors	0.3									
Projection & Bale.	0.5									
Sub-Total	12.7									
Fittings Fixt. and Equipment										
Non-Instructional	1.7									
Instructional	4.5									
Sub-Total	6.2									
Cash Allowance										
Hardware	1.6									
Testing and Inspect.	0.3									
Sub-Total	1.9									

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Plumbing and Drains										
Roughing-In (O)	1.9									
Roughing-In (S)	0.6									
Plumbing Fixt. (O)	0.5									
Plumbing Fixt. (S)	0.1									
Fire Protection	0.5									
Special Services	1.3									
Sub-Total	4.9									
Heating Vent. Air Conditioning										
H.V.A.C.	14.5									
Special Systems	2.8									
Sub-Total	17.3									

(1)	(2)	(3)						(4)	(5)	(6)
Group Element and Element	Avge. Elmt. %age	At 10	At 20	At 30	At 40	At 50	At 60	%age of Element Replaced	% of Total Replaced	Sub-Total % as % of Total % Repl.
Electrical										
Transformers	2.7									
Lighting & Wiring	5.4									
Underfloor Ducts	0.6									
Special Systems	4.3									
Sub-Total	13.0									
Total	100%									
Indirect and General	8.6									
Professional Fees	10.0									
Contingencies	3.0									
Total percentage (excluding furniture and equipment)										

UNIVERSITY

OUTLINE DESCRIPTION OF THE SCOPE AND THE COST OF MAJOR ALTERATION PROJECTS

PROJECT NUMBER	PROJECT NAME	YEAR OF ALTERATION	TOTAL PROJECT COST

SCOPE OF THE PROJECT

COST BREAKDOWN

	$	%	%	$/NASF	% ALTN/RENOV
Architectural					
Built-in Furniture					
Built-in Equipment					
Allowances					
Mechanical					
Electrical					
Other					
- Net Building Cost					
Professional Fees					
Contingency					
Furniture					
Equipment					
- Total Project Cost					

N.A.S.F. Area Altered or Renovated =

APPENDIX 4

LAW BUILDING DATA

Page

Capital cost analysis 1-3

Operating and maintenance costs:

- Building Maintenance 4
- Custodial Services 5
- Utilities 6

Cyclical renewal:

- Renovations (structure and totals) 7
- Renovations (mechanical only) 8
- Renovations (electrical only) 9
- Equipment replacement 10
- Furniture replacement 11

Law Building
University of Windsor

CAPITAL COST ANALYSIS

(Excludes overhead, profit, site development, fees, federal sales tax)

Sheet 1 of 3

No.	ELEMENT	ELEMENTAL COST			AMOUNT		UNIT RATE/OGSF		%
		Quantity	Unit Rate	Unit of Measure	Sub-Element	Element	Sub-Element	Element	
1	INDIRECT & GENERAL EXPENSES	-	-	-	-	-	-	-	-
2	SUBSTRUCTURE	29,700	3.35	SF Grade Area		99,380		1.17	5.3
	a) Normal Foundations	275	85.75	CY Concrete	23,580		0.28		
	b) Basement Excavations	175,811	0.09	CF Basement Vol.	15,540		0.18		
	c) Special Foundations	-	-	Caisson Piling	60,260		0.71		
3	HORIZONTAL STRUCTURAL ELEMENTS	116,933	3.99	SF Struct. Area		467,070		5.49	24.6
	a) Slabs on Grade	29,700	0.68	SF Slab Area	20,050		0.24		
	b) Floor & Roof Construction	87,233	4.55	SF Slab Area	396,480		4.66		
	c) Roof Finish	32,905	1.53	SF Roof Finish	50,540		0.59		
4	EXTERIOR CLADDING	46,480	5.22	SF Wall Area		242,750		2.85	12.9
	a) Walls Below Grade	4,737	2.84	SF Wall Area	13,440		0.16		
	b) Walls Above Grade	27,806	4.16	SF Wall Area	115,630		1.35		
	c) Windows	9,566	10.38	SF Window Area	99,280		1.17		
	d) Exterior Doors, Entrances, Screen	571	11.77	SF Opening Area	6,720		0.08		
	e) Projections, Balconies, Etc.	3,800	2.02	SF Soffit	7,680		0.09		
5	INTERIOR VERTICAL ELEMENTS	66,208	1.95	SF Part. Area		129,140		1.52	6.9
	a) Partitions	61,560	1.39	SF Part. Area	85,520		1.00		
	b) Folding or Sliding Partitions	1,120	18.77	SF Part. Area	21,020		0.25		
	c) Doors	168	135.	Per Door Leaf	22,600		0.27		

Law Building
University of Windsor

CAPITAL COST ANALYSIS

(Excludes overhead, profit, site development, fees, federal sales tax)

Sheet 2 of 3

No.	ELEMENT	ELEMENTAL COST			AMOUNT		UNIT RATE/OGSF		%
		Quantity	Unit Rate	Unit of Measure	Sub-Element	Element	Sub-Element	Element	
6	MULTI-STOREY ELEMENTS	-	-	-	-	63,270	-	0.74	3.3
	a) Stairs, Steps & Ladders	23	1700.	Per Flight	39,160		0.46		
	b) Catwalks, Gratings	-	-	SF on Plan	-		-		
	c) Elevators & Hoists	4	6030.	Per Stop	24,110		0.28		
	d) Escalators	-	-	Per Floor	-		-		
7	INTERIOR FINISHES	-	-	-		204,920		2.41	10.9
	a) Floor Finishes	82,000	0.87	SF Finished Area	71,580		0.84		
	b) Ceiling Finishes	82,000	0.94	SF Finished Area	76,960		0.90		
	c) Wall Finishes	128,000	0.44	SF Fin.Wall Area	56,380		0.67		
	d) Special Finishes	-	-		-		-		
8	FITTINGS, FIXTURES & EQUIPMENT	-	-	-	-	62,570		0.73	3.3
	a) Non Instructional	-	-	-	32,740		0.38		
	b) Instructional	-	-	-	29,830		0.35		
9	CASH ALLOWANCES	-		-		25,450		0.30	1.4
	a) Hardware	188	118.	Per Unit	22,150		0.26		
	b) Inspections and Testing	-	-	-	3,300		0.04		

Law Building
University of Windsor

CAPITAL COST ANALYSIS
(Excludes overhead, profit, site development, fees, federal sales tax)

Sheet 3 of 3

No.	ELEMENT	ELEMENTAL COST			AMOUNT		UNIT RATE/OGSF		%
		Quantity	Unit Rate	Unit of Measure	Sub-Element	Element	Sub-Element	Element	
10	PLUMBING & DRAINS	-	-	-		61,660		0.72	3.3
	a) Roughing-in (Standard)	56	836.	Per Fixture	49,610		0.58		
	b) Roughing-in (Special)	-	-	Per Fixture	-				
	c) Plumbing Fixtures (Standard)	56	196.	Per Fixture	10,950		0.13		
	d) Plumbing Fixtures (Special)	-	-	Per Fixture	-				
	e) Fire Protection	23	48.0	Per Cabinet or Per Head	1,100		0.01		
	f) Special Services	-	-	Per Outlet	-				
11	HEATING, VENTILATING & AIR COND'G	-	-	-		322,960		3.79	17.1
	a) HVAC	85,140	3.79	-	322,960		3.79		
	b) Special Systems	-	-	-	-				
12	ELECTRICAL	-	-	-		202,500		2.38	10.8
	a) Transformers & Distribution	85,140	0.62	-	52,470		0.62		
	b) Lighting Fixtures & Branch Wiring	85,140	1.16	-	99,060		1.16		
	c) Underfloor Duct Systems	85,140	0.60	-	51,060		0.60		
	d) Special Systems	-	-	-	-				
	Total, as tendered, includes change orders					1,881,760		22.10	100.

OPERATING AND MAINTENANCE COSTS

(Actual dollars; allocated to building elements)

Law Building
University of Windsor

Building Maintenance

No.	Element	1969-1970 (1 Month)	1970-1971 (12 Months)	1971-1972 (12 Months)	1972-1973 (11 Months)	Totals (36 Months)
1	Indirect & General Expenses	-	-	-	-	-
2	Substructure	-	-	-	-	-
3	Horizontal Structural Elements	-	40	201	-	241
4	Exterior Cladding	-	157	664	816	1,637
5	Interior Vertical Elements	-	389	243	452	1,084
6	Multi-Storey Elements	-	-	891	785	1,676
7	Interior Finishes	-	119	145	18	282
8	Fittings, Fixtures & Equipment	-	758	789	668	2,215
9	Cash Allowances	-	457	979	225	1,661
10	Plumbing & Drains	-	310	240	746	1,296
11	Heating, Vent'g. & Air Cond'g.	-	3,598	1,909	1,414	6,921
12	Electrical	-	1,655	1,209	1,454	4,318
	Yearly Totals $	-	7,483	7,270	6,578	21,331

OPERATING AND MAINTENANCE COSTS
(Actual dollars; allocated to building elements)

Law Building
University of Windsor

Custodial Services

No.	Element	1969-1970 (1 Month)	1970-1971 (12 Months)	1971-1972 (12 Months)	1972-1973 (11 Months)	Totals (36 Months)
1	Indirect & General Expenses	-	-	-	-	-
2	Substructure	-	-	-	-	-
3	Horizontal Structural Elements	-	-	-	-	-
4	Exterior Cladding	43	1,903	1,609	1,460	5,015
5	Interior Vertical Elements	-	-	-	-	-
6	Multi-Storey Elements	-	-	-	-	-
7	Interior Finishes	1,110	47,166	40,862	37,328	126,466
	Fittings, Fixtures & Equipment	340	3,848	4,170	4,106	12,464
	Cash Allowances	-	-	-	-	-
	Plumbing & Drains	39	1,302	1,054	956	3,351
	Heating, Vent'g. & Air Cond'g.	-	-	-	-	-
12	Electrical	90	3,027	2,713	2,487	8,317
	Yearly Totals $	1,622	57,246	50,408	46,337	155,613

OPERATING AND MAINTENANCE COSTS

(Actual dollars; allocated to building elements)

Utilities

No.	Element	1969-1970 (1 Month)	1970-1971 (12 Months)	1971-1972 (12 Months)	1972-1973 (11 Months)	Totals (36 Months)
1	Indirect & General Expenses	-	-	-	-	-
2	Substructure	-	-	-	-	-
3	Horizontal Structural Elements	-	-	-	-	-
4	Exterior Cladding	-	-	-	-	-
5	Interior Vertical Elements	-	-	-	-	-
6	Multi-Storey Elements	-	-	-	-	-
7	Interior Finishes	-	-	-	-	-
8	Fittings, Fixtures & Equipment	-	-	-	-	-
9	Cash Allowances	-	-	-	-	-
10	Plumbing & Drains	21	252	254	216	743
11	Heating, Vent'g. & Air Cond'g.	2,050	24,594	20,594	20,438	67,676
12	Electrical	1,246	14,996	15,833	19,073	51,148
	Yearly Totals $	3,317	39,842	36,681	39,727	119,567

CYCLICAL RENEWAL

Renovations (Structure and totals) Sheet 1 of 3

[illegible]	Element	Description	Original Capital Cost	Removal Cost	Renewal Cost	Years when renewed												Replacements	Replac'm't Cost
						5	10	15	20	25	30	35	40	45	50	55	60		
Gen'l Contractor	3 (a,b)	Replace expansion joints	900	200	1100						x						x	2	2,200
Roofing	3 (c)	Replace entire roofing	52650	8250	60900								x					1	60,900
		Resurface roof	21400	4000	25400				x								x	2	50,800
Gen'l Cont & Wprfg.	4 (a)	Replace membrane waterproofing & weep tile																	
		Excav. & B/Fill	5500		5500						x						x	2	11,000
		Weeping Tile	1500	250	1750						x						x	2	3,500
		Waterproofing	2370	600	2970						x						x	2	5,940
		Sod & Paving Repairs	1000	1000	2000						x						x	2	4,000
Masonry	(b)	Repoint brickwork and clean down	30000	14000	44000							x						1	44,000
Caulking	(c,d)	Replace caulking to all windows and entrances	4000	400	4400			x			x			x			x	4	17,600
Gen'l Cont & HM.DR.	(d)	Replace HM. doors and frames	3400	1700	5100								x					1	5,100
Gen'l Cont & FHW	9 (a)	Replace finishing hardware - ext. doors	3200	850	4050								x					1	4,050
Lath & Plaster	(e)	Replace stucco soffits	8000	1000	9000						x						x	2	18,000
Gen'l Cont & Masonry	5 (a)	Replace 5" partitions	4450	1450	5900				x				x				x	3	17,700
Folding Partition	(b)	Replace folding partitions	21900	500	22400						x						x	2	44,800
Gen'l Cont & HM.DRS.	(c)	Replace doors and frames	16000	8000	24000								x					1	24,000
Gen'l Cont & QT.	6 (a)	Replace stair wearing surfaces	4000	1000	5000								x					1	5,000
Gen'l Cont & QT.	7 (a)	Replace quarry tile	24800	3000	27800								x					1	27,800
Carpet	(a)	Replace carpet	37850	3250	41100		x		x		x		x		x		x	6	246,600
Resilient Tile	(a)	Replace resilient tile	13900	3650	17550			x			x			x			x	4	70,200
Acoustic Tile	(b)	Replace ceilings	71970	7000	78970						x						x	2	157,940
	(c)	Replace applied wall finishes	16500	2000	18500						x						x	2	37,000
Painting	(b,c)	Repaint	39000		39000		x		x		x		x		x		x	6	234,000
Gen'l Cont & Millwork	8 (a,b)	Replace fittings & fixtures (50%)	32600	3000	35600										x				35,600
		Replace lockers	13000	750	13750			x			x			x			x	4	55,000
Gen'l Cont & FHW	9	Replace finishing hardware (20%)	4600	1150	5750								x					1	5,750
Mech. contractor	10)) 11)	) Mechanical) See attached)	395610																182,350
Elect. Contractor	12	Electrical (see attached)	219750																144,340
		TOTALS	$ 1,049,850																$ 1,515,180

CYCLICAL RENEWAL

Renovations (mechanical only)   Sheet 2 of 3

[illegible]	Element	Description	Original Capital Cost	Removal Cost	Renewal Cost	Years when renewed												Replacements	Replace't Cost
						5	10	15	20	25	30	35	40	45	50	55	60		
Mechanical	Plumbing & Drainage (10)	Roughing in	31,200	5,000	3,120					x					x			2	16,240
		Plumbing fixtures	10,000	2,000	2,000					x					x			2	8,000
		Domestic hot water system	2,400	1,000	2,400					x					x			2	6,800
		Sump pumps	700	200	140										x			1	340
		Fire protection	800	200	160										x			1	360
		Sitework	21,000	500	2,100										x			1	2,600
	HVAC (n)	Mechanical equipment, incl. AC unit, pumps, pipes	68,300	1,000	27,320				x				x				x	3	84,960
		Sheet metal, incl. fans, grilles, diffusers, dampers	201,600	10,000	40,320										x			1	50,320
		Insulation	38,200	1,000	3,820										x			1	4,820
		Controls	21,400	1,500	6,420										x			1	7,920
		Totals	$ 395,600																$ 182,360

BEST COPY AVAILABLE

CYCLICAL RENEWAL

Renovations (electrical only) Sheet 3 of 3

[illegible]	Element	Description	Original Capital Cost	Removal Cost	Renewal Cost	Years when renewed 5	10	15	20	25	30	35	40	45	50	55	60	Replacements	Replace't Cost
Electrical		Incoming underground service	10,000	1,000	6,000						x						x	2	14,000
		Substation	18,000	500	3,600						x						x	2	8,200
		Lighting panels	6,900	500	1,700				x				x				x	3	6,600
		Feeders	13,200	1,000	3,960						x						x	2	9,920
		Lighting fixtures	82,000	2,000	16,400					x					x			2	36,800
		Contactors	5,100	50	510		x		x		x		x		x		x	6	3,360
		P.B. Station	400	50	200					x					x			2	500
		Disconnect	50	10	25					x					x			2	70
		Motor control center	10,000	100	1,000		x		x		x		x		x		x	6	6,600
		Motor connectors	5,000	500	1,500						x						x	2	4,000
		Emergency generator	3,500	100	350						x						x	2	900
				200	1,050										x			1	1,250
		Lamps	4,200	Maintenance														-	-
		Branch wiring	22,200	2,000	6,660						x						x	2	17,320
		Fire alarm system	15,500	1,000	3,100					x					x			2	8,200
				1,500	4,650										x			1	6,150
		Clock system	4,500	400	900					x					x			2	2,600
				700	1,350										x			1	2,050
		Telephone conduit	2,500	-	-													-	-
		P/A system	5,000	400	1,000					x					x			2	2,800
				700	1,500										x			1	2,200
		Audio system	5,500	400	1,100					x					x			2	3,000
				700	1,650										x			1	2,350
		Closed circuit T.V.	200	Equipment														-	-
		Door alarm system	6,110	300	1,220					x					x			2	3,040
				500	1,930										x			1	2,430
		Totals	$ 219,860																$ 144,340

EQUIPMENT REPLACEMENT ANALYSIS

Law Building
University of Windsor

Item	Life	Initial Cost	Removal	5	10	15	20	25	30	35	40	45	50	55	60	Replace-ments	Replacement Cost
Electrical Components	15	1,660				X			X			X			X	4	6,640
Projector and Table	10	665			X		X		X		X		X		X	6	3,990
Hot plate	10	65			X		X		X		X		X		X	6	390
Refrigerator	10	135			X		X		X		X		X		X	6	810
Kardex Table and File	15	595				X			X			X			X	4	2,380
Typewriters	10	6,220			X		X		X		X		X		X	6	37,320
Electric Stapler	10	70			X		X		X		X		X		X	6	420
Mastermaker & Processor	10	420			X		X		X		X		X		X	6	2,520
Collator and Stacker	10	1,140			X		X		X		X		X		X	6	6,840
Money Box	10	15			X		X		X		X		X		X	6	90
Microfilm Cabinet	10	190			X		X		X		X		X		X	6	1,140
Graphic Panels	25	570						X					X			2	1,140
Plaques and Lettering	25	410						X					X			2	820
Shelving	50	69,330	2,000										X			1	71,330
Trucks (book and hand)	10	2,725			X		X		X		X		X		X	6	16,350
		84,210															152,180

FURNITURE REPLACEMENT ANALYSIS

Law Building
University of Windsor

Item	Life	Initial Cost	5	10	15	20	25	30	35	40	45	50	55	60	Replacements	Replacement Cost
Furniture																
Wood: Tables	20	10,660				X				X				X	3	31,980
Chairs	15	41,255			X			X			X			X	4	165,020
Credenzas	20	250				X				X				X	3	750
Bookcases	20	8,515				X				X				X	3	25,540
Wardrobes	20	355				X				X				X	3	1,060
Sofas	10	3,060		X		X		X		X		X		X	6	18,360
Cabinets	20	1,795				X				X				X	3	5,380
Desks	20	865				X				X				X	3	2,590
Carrels	20	28,520				X				X				X	3	85,560
Miscellaneous	10	135		X		X		X		X		X		X	6	810
Steel: Cabinets	20	11,120				X				X				X	3	33,360
Tables	20	8,515				X				X				X	3	25,540
Desks	20	18,940				X				X				X	3	56,820
Credenzas	20	305				X				X				X	3	910
Chairs	15	11,115			X			X			X			X	4	44,460
Card Catalogues	15	1,385			X			X			X			X	4	5,540
Wastebaskets	10	1,100		X		X		X		X		X		X	6	6,600
Accessories	10	1,010		X		X		X		X		X		X	6	6,060
Furnishings																
Drapes	10	4,400		X		X		X		X		X		X	6	26,400
		153,300														542,740

SURVEY OF DATA AVAILABILITY

The Task Force made a survey of the 14 Ontario universities in order to establish the availability of building operating and maintenance costs for individual buildings. This information was required in order to establish the data base that might be available, or the work involved to extract the data from physical plant records, should a major study of life costs be undertaken upon the completion of this pilot study. Replies were received from 11 of the 14 universities.

The most important question, question No. 1, established that only 5 universities were currently maintaining records for individual building operating and maintenance costs in line with the form of analysis recommended by the Ontario Association of Physical Plant and Planning Administrators and the Committee of Finance Officers of the Universities of Ontario. It should be noted that this form of analysis was available for total operating and maintenance costs in all of the universities. However, three more universities were presently studying or intending to use the format in the near future for individual buildings.

For maintenance costs alone, 7 universities maintained records by building, with the majority of these being available for 100% of the campus space. The number of past years for which this information was available varied from one to ten years. Most of the other universities indicated that it would be very difficult, time consuming, or impossible to obtain this information from current records on an individual building basis, for the last few years.

Seven universities maintain housekeeping costs by building, for periods up to the past ten years. For housekeeping, the remaining universities were more optimistic about their ability to provide this information by analysis of past records.

On the subject of utilities, the same 7 universities were in a position to supply the costs of some or all of the individual utilities to some or all of their buildings. The remaining universities noted that there were considerable costs involved in metering all utilities to all buildings where this was not already being carried out. However, the main report of the Task Force contains some comments on how this problem might be overcome in the future.

Only 4 universities replied that their records were able to identify renovations and major repair costs for individual buildings, without further analysis. Here again, the remaining universities were pessimistic about their ability to obtain this information by an analysis of past records.

The tabulation on the following page is a summary of the responses and must be read in conjunction with the survey questionnaire which follows the tabulation.

Task Force on Life Costs

Summary of Responses to Survey on Availability of Building Operating and Maintenance Cost Data

	Question No. 1			Question No. 3			Question No. 4			Question No. 5				Question No. 6		
University	Maintain OAPPPA/COFOUO records for individual buildings?	How many past years?	If NO, intend to start?	% Campus GSF for buildings with individual maintenance costs	How many past years?	Attitude to analyzing past records to obtain indiv. bldg. mtce. costs (3)	% Campus GSF for bldgs with individual custodial costs	How many past years?	Attitude to analyzing past records (3)	% Campus GSF for bldgs with individual utilities costs	How many past years?	Attitude to analyzing past records (3)	Comments	Do records identify renovations and major repair costs for individual bldgs?	How many years?	Attitude to analyzing past records (3)
Brock	No	n.a.	No	30	2	-	30	2	-	100	3	n.a.	power only, other services not used/ metered	partial	2	-
Carleton	No	n.a.	Yes	nil	n.a.	-	100	3-4	-	20	0-2		power, gas only,""""	yes	2-3	-
Guelph	No	n.a.	(5)	100	1	-	nil	n.a.	+	nil	n.a.	-		yes	7	n.a.
Lakehead	No	n.a.	Yes	nil	n.a.	-	nil	n.a.	-	nil	n.a.	-		no	n.a.	-
Laurentian																
McMaster	Yes	10	n.a.	100	10	n.a.	100	10	n.a.	100	10	n.a.		no	n.a.	+
Ottawa	No	n.a.	No	nil	n.a.	+	nil	n.a.	+	nil	n.a.	+		no	n.a.	-
Queen's	No	n.a.	No	nil	n.a.	-	nil	n.a.	-	100	10	n.a.	water only, other services not metered	no	n.a.	-
Toronto																
Trent																
Waterloo	Yes	2	n.a.	100	2	n.a.	100	3	n.a.	0-45	0-3	-		no	n.a.	-
Western Ontario	Yes/ No	6	Yes	75	6	-	75	6	-	nil	n.a.	-		no	n.a.	-
Windsor	Yes	3	n.a.	100	3	n.a.	100	3	n.a.	100	3	n.a.		yes	3	n.a.
York	Yes	5	n.a.	100	5	n.a.	100	5	n.a.	100	5	n.a.		yes	5	n.a.

Notes:
1. Blank spaces indicate no reply received from university, or to particular question.
2. n.a. means not applicable.
3. + indicates that existing records could be analyzed with probable success; - indicates unlikely that data could be obtained from existing records.
4. See survey form for full description of question. 5. Studying whether to or not.

July 20, 1973

UNIVERSITY OF GUELPH · GUELPH · ONTARIO · CANADA
N1G 2W1
AREA CODE 519 · 824-4120

June 14, 1973

Re: C.O.U./OAPPPA Task Force on Building Life Costs

Dear

During the recent OAPPPA Meeting at Brock University, there was discussion on the subject of availability of building operating and maintenance costs. Attached to this letter, is a questionnaire which is designed to provide information on the availability of such data for individual buildings on your campus. The Task Force does not want to know what these costs are, at this time, but wishes to establish the data base that might be available, or the work involved to extract the data from physical plant records, should C.O.U. decide to undertake a major study of life costs in the future.

It would be appreciated, if you could complete and return the questionnaire to me, by June 27, 1973. If there are any queries, please contact me.

Your co-operation is appreciated.

Yours very truly,

H. Graupner
Chairman
C.O.U./O.A.P.P.P.A. Task Force on
Life Costs

HG:mw

Att'd

C.O.U./O.A.P.P.P.A. Task Force on Life Costs

Questionnaire on Data Availability re Operating and Maintenance Costs for Individual Buildings

PLEASE ANSWER THE FOLLOWING QUESTIONS

1. (a) Do you now maintain a separate record of physical plant costs for each individual building in line with the O.A.P.P.P.A./C.O.F.O.-U.O. classification system*? ....
   (b) If the answer to 1 (a) is YES but only for some buildings, please state why you are keeping separate records for these buildings:
   ....
   ....
   ....
   (c) If the answer to 1 (a) is YES, for how many completed years, is the data available for individual buildings in the O.A.P.P.P.A./C.O.F.O.-U.O. format? .... years
   (d) If the answer to 1 (a) is NO for any or all buildings, do you plan to start maintaining them in this format in the future? ....
   when? ....
2. Do you have a list showing, for each of your buildings, which services, utilities, are individually metered? ....
   If YES, please attach a copy, so that the Task Force can prepare a composite statement on the amount of individual metering presently being carried out. (Published results will not identify any specific University).

If your answer to 1 (a) was an unqualified YES, ignore the remaining questions.

3. (a) For how many of your buildings, do your current records readily identify (i.e. without further analysis or estimating) the total annual building maintenance cost on an individual building basis?
   .... buildings
   (b) This number of buildings is about ....% of the total number of buildings/total gross square footage (delete one)
   (c) For how many past years, is this data readily available?........ years.

* A summary of this classification system, follows the questions.

3. (d) If building maintenance costs are available only on an aggregated basis for groups of buildings, or for the entire campus, please comment on the possibility of analyzing your records with the object of assessing individual costs for a number of the more significant buildings on your campus, for a number of years (say 3 or 5): ....
....
....

4. For custodial services, answer similar questions to those in 3 (a) - (d) above.
(a) ....
(b) ....% of buildings on campus/total gross square footage (delete one)
(c) ....
(d) ....
....
....

5. For utilities, answer similar questions to those in 3 (a) - (d) above.

	Electric Power	Gas	City Water	Steam	Sewage	Chilled Water	Compressed Air	Fuel Oil
(a)	....	.....	.....	.....	......	....	....	....
(b)	....	.....	.....	.....	......	....	....	....
(c)	....	.....	.....	.....	......	....	....	....

(d) ....
....
....

6. (a) For renovations, alterations and major repairs, carried out from operating budgets, do your records readily identify the costs for individual buildings on an annual or project basis? ....
(b) If the answer to 6 (a) is YES, for how many past years, would the information be readily accessible? .... years
(c) If the answer to 6 (a) is NO, please comment on the possibility of analyzing your records with the object of assessing costs for individual buildings, for the past 3 or 5 years: ....
....
....
....

7. Please note here, whether above answers include or exclude residences:
....
....
....

Classification System for Operating and Maintenance Costs per O.A.P.P.P.A./ C.O.F.O.-U.O.

Operating and maintenance costs for an individual building are made up of the following costs, as defined by the Committee of Finance Officers - Universities of Ontario and by the Ontario Association of Physical Plant Administrators:-

1. Physical Plant Administration

   The task force does not consider this item to be a direct part of the life cost of a building, and this questionnaire does not cover this function.

2. Building Maintenance

   Building maintenance includes all items related to routine repair of buildings and structures, including normal recurring repairs and preventive maintenance. Does not include cost of service for which reimbursement is received from other sources such as ancillary enterprises, new construction, alterations, etc. In addition to the maintenance of the fabric and structure of the building include the following:

   2.1 Salaries, wages and employee benefits of all hourly-rated personnel and first-line salaried personnel.

   2.2 Interior and exterior of buildings

   2.2.1 Plumbing, heating, air conditioning, and ventilation

   2.2.2 Electrical repairs of all types excluding primary systems and primary building sub-stations but including secondary systems, lamp replacements and maintenance of outdoor building lighting fixtures.

   2.2.3 Carpentry and cabinet making

   2.2.4 Painting and glazing

   2.2.5 Hardware, locks, keys, closers and records

   2.2.6 Roofing and sheet metal work, including downspouts and gutters

   2.2.7 Welding and necessary machine work

   2.2.8 Elevators and other building machinery

   2.2.9 Miscellaneous building repairs such as tuckpointing, blinds, etc.

   2.3 Maintenance of all furniture, furnishings and equipment within the building (exclude maintenance covered by user).

2.4 Maintenance of utility distribution systems inside the building. Electrical, heating, cooling, process steam, water lines, gas lines and sewer lines (both storm and sanitary), etc.

2.5 Operating and replacement costs of all equipment and material and tools used in connection with building maintenance excluding hand tools furnished by the employees.

3. Custodial Services

Includes all costs related to janitorial and custodial services to buildings and structures including care and waxing of floors, washing of windows and costs of all cleaning contracts let to outside cleaning contractors (including window-washing).

3.1 Salaries, wages and employee benefits of all hourly-rated personnel and first-line salaried personnel

3.2 Small set ups only where materials for the special set ups are stored or kept within the same building

3.3 Snow removal immediately adjacent to building

3.4 Other operating costs such as paper, paper towels and tissue, wax, erasers, chalk, cleaners, and other materials and supplies

3.5 Operating and replacement costs of all equipment used in connection with custodial services and certain lamp replacement

4. Utilities

Utility services include all costs for energy for heating, cooling, light and power, gas, water, telephone equipment and rental costs and any other utilities necessary for the operation of the physical plant and normally includes:

4.1 Salaries, wages and employee benefits of all hourly-rated personnel and first-line salaried personnel

4.2 Operation and maintenance of heating and power plant equipment including water plant and sewage disposal plants

4.3 Operation and maintenance of equipment in central air-conditioning plant

4.4 Contractual costs for purchase of electricity, gas, water, telephone equipment and rentals and sewage treatment

4.5 Operation and replacement costs of all equipment used in connection with production of utilities

4.6 Maintenance of utility tunnels, distribution systems external to buildings for electricity, gas, steam, compressed air, chilled water, and high temperature water, domestic water, sanitary and storm drains. The expense does not include open ditch drainage and street, walks and grounds lighting maintenance.

5. Landscape and Grounds Maintenance)
)
6. Safety, Security and Traffic) Not covered by this survey
)
7. Other)

8. Renovations, Alterations and Major Repairs

   Major repairs of a non-recurring nature in excess of $10,000 and all renovations and alterations. Repairs and refurbishing under $10,000 are to be included by their object, e.g. costs of labour, material or external contracted services, under the function of Building Maintenance.

   8.1 Salaries, wages and employee benefits of all hourly-rated personnel and first-line salaried personnel

   8.2 Replacement costs of all furniture, furnishings, equipment and services required in connection with major repairs and renovations and alterations.

Further clarification of this cost breakdown and of definitions, may be obtained from the O.A.P.P.P.A.-C.O.F.O.-U.O. Document "Reporting of the Expenses by Major Function for the Operating Fund Function" "Physical Plant" for the Universities of Ontario", dated May 24, 1973 and the July 1972 "Physical Plant Classification of Functions".

COMPUTER PROGRAM FOR LIFE COST PROJECTIONS

Input required by the life cost computer program is illustrated by the attached computer printout of the input for the first case analyzed for the University of Windsor Law School Building (namely, no post-1973 cost inflation apart from the effects of general price inflation). The vector of cash flows (re-stated in 1973 dollars) calculated from this input is also attached.

Input items are keyed to items in the input printout.

1. Length of cash flows vector (number of years for which cost expenditures are calculated).

2. Number of cost horizons for which total life costs are calculated.

3. Anticipated general price inflation rate per annum, in mills.

4. Fraction of replacement cycle costs spread over cycle rather than expended at end of cycle (may be overridden for specific costs).

5. Year in terms of which all costs are to be re-stated.

6. Cost horizons to be used in table.

7. Cost increase data for each category of operating costs (categories 2 to 4) and for construction and renovations (category "0"). Adjustment values represent the percentage increase in prices between costs in each year and costs in 1973. For operating costs, these are obtained from the detailed cost index data presented in Appendix 8; for construction costs, they are Southam construction cost indices for Ontario adjusted by the ratio (18/31) of actual cost increases to the change in the Southam index obtained from a detailed analysis reported in Building Blocks Volume 4.

8. Capital costs are read in separately for net cost and overhead components of costs for each cost element.

9. Year in terms of which construction costs are defined.

10. Year in which construction started.

11. Year in which building occupied.

12. Operating costs are read in as the sum of historical costs for each category over a number of years. Total shown is average total cost per year. Operating costs are assumed to include all regular-cost items incurred annually.

13. Mid-point of period (year in terms of which operating cost figures are defined).

14. Number of years in period for which historical costs are read in.

15. End of period.

16. Replacement items include all cyclic renewal items as well as periodic renovations.

17. Year in terms of which replacement costs are defined.

18. Total cost of renewal including removal of previous fixtures and capital cost of item replaced.

19. Length of renewal cycle.

20. Fraction of total renewal cost spread evenly over all years in cycle; remainder is assumed to be incurred at end of cycle.

21. Average annual operating and renewal costs, unadjusted for price changes before 1973 or for subsequent inflation.

22. Vector of expenditures calculated for each year from input data, after adjustment for price changes before 1973 and for changes in relative prices and efficiency of use of labour and materials, but excluding the effect of any post-1973 general price inflation.

INPUT FOR LIFE COST PROJECTION

Sheet 1 of 2

```
INPUT FOR LIFE COST ANALYSIS

$PARAMETERS                        200①    7②    35③    0④  1973⑤     0

$HORIZONS⑥                         30  40  50  60  75 100 125
$COST INCREASES⑦

              RELATIVE PRICE INFLATION   RATE OF INCREASE IN
CATEGORY     THRU 1990     POST-1990      INPUT REQUIREMENTS

   1            0.0           0.0               0.0
   2            0.0           0.0               0.0
   3            0.0           0.0               0.0
   4            0.0           0.0               0.0

ADJUSTMENTS TO NORMALIZE PRE-BASE YEAR FIGURES TO 1973
STARTING
 YEAR       ADJUSTMENT VALUES

1969          0.36 0.26 0.17 0.08
1969          0.35 0.24 0.15 0.08
1969          0.37 0.26 0.16 0.11
1969          0.17 0.11 0.07 0.03

$CAPITAL COSTS⑧                   1973⑨  1969⑩  1970⑪    0        0        0

ELEMENT       TITLE                  NETCOST       OVERHEADS

     1     STRUCTURE                 515910.        58800.
     2     ENVELOPE                  293290.        33470.
     3     INTERIORS                 485350.        55370.
     4     ME SYSTEMS                567210.        66960.
     5     FURNITURE+EQUIP.          237510.            0.

           TOTALS                   2119270.       214600.

      NOTE: COSTS ARE DEFINED IN 1973 TERMS

$OPERATIONS⑫                      1971⑬     3⑭  1972⑮  1970⑪      0        0

                                    COST FOR
ELEMENT       TITLE               3-YEAR PERIOD     (PERIOD ENDING IN  1972)

     1     ADMINISTRATION               0.
     2     MAINTENANCE              21330.
     3     CUSTODIAL               155610.
     4     UTILITIES               119570.

           TOTALS                   59837.
```

INPUT FOR LIFE COST PROJECTION

Sheet 2 of 2

```
$REPLACEMENTS ⑯                  1[illegible] ⑰  1970 ⑰      0          0          (          )

ELEMENT      TITLE                      COST ⑱         CYCLE ⑲      FRACTION ⑳
                                                                      SPREAD

  3AB       EXPANSION JOINTS           1[illegible]00.           30          0.0
  3C        ROOFING SURFACE            [illegible]54[illegible]0.           20          0.0
  3C        ROOF REPLACE               35500.           40          0.0
  4A        WATERPROOFING              12220.           30          0.0
  4B        REPOINT BRICKS             74000.           35          0.0
  4CD       CAULKING                    4400.           15          0.0
  4D        HM DOORS                    51[illegible].           40          0.0
  9A        DOOR HARDWARE               4050.           40          0.0
  4F        STUCCO SOFFITS              9000.           30          0.0
  5A        S & PARTITIONS              5500.           20          0.0
  5B        FLDG. PARTITION            22400.           30          0.0
  5C        DOORS & FRAMES             24000.           40          0.0
  6A        STAIR SURFACES              5[illegible]2.           40          0.0
  7A        QUARRY TILE                27600.           40          0.0
  7A        CARPET                     41120.           10          0.0
  7A        RESILIENT TILE             17550.           15          0.0
  7B        CEILINGS                   78970.           30          0.0
  7C        APPLIED FINISHES           16500.           30          0.0
  7C        REPAINT                    35[illegible].           1[illegible]          0.0
  8AB       50% FITTINGS+EXT           35600.           50          0.0
  9         20% FINISHING HW            5750.           40          0.0
  10        PLUMBING A                 15520.           25          0.0
  10        PLUMBING B                  3300.           50          0.0
  11        MECHANICAL A               31320.           20          0.0
  11        MECHANICAL B               63060.           50          0.0
  12        ELECTRICAL A                1660.           10          0.0
  12        ELECTRICAL B               22[illegible].           2[illegible]          0.0
  12        ELECTRICAL C               28505.           25          0.0
  12        ELECTRICAL D               27170.           30          0.0
  12        ELECTRICAL E               1643[illegible].           50          0.0
  13        FURNITURE A                 9705.           10          0.0
  13        FURNITURE B                53755.           15          0.0
  13        FURNITURE C                8984[illegible].           20          0.0
  14        EQUIPMENT A                11650.           10          0.0
  14        EQUIPMENT B                 2265.           15          0.0
  14        EQUIPMENT C                  98[illegible].           25          0.0
  14        EQUIPMENT D                71330.           50          0.0
  15        RENOVATIONS               104360.            6          0.0

AVERAGE YEARLY ONGOING COSTS AFTER 1970 ($000, UNADJUSTED INPUT) =       154.648 ㉑
```

VECTOR OF CASH FLOWS

```
FLOWS VECTOR IN 1973 DOLLARS ($000) ㉒

 1166.935  1166.935   111.026   111.026   111.026   253.269   111.026   111.026   111.026   251.572
  111.026   253.269   111.026   111.026   217.285   111.026   111.026   253.269   111.026   442.373
  111.026   111.026   111.026   253.269   172.368   111.026   111.026   111.026   111.026   730.911
  111.026   111.026   111.026   111.026   17 .996   253.269   111.026   111.026   111.026   608.486
  111.026   253.269   111.026   111.026   217.285   111.026   111.026   253.269   111.026   571.501
  111.026   111.026   111.026   253.269   111.026   111.026   111.026   111.026   111.026   941.712
  111.026   111.026   111.026   111.026   111.026   253.269   111.026   111.026   111.026   311.543
  111.026   253.269   111.026   111.026   278.627   111.026   111.026   253.269   111.026   608.466
  111.026   111.026   111.026   253.269   111.026   111.026   111.026   111.026   111.026   73 .911
  111.026   111.026   111.026   111.026   111.026   253.269   111.026   111.026   111.026   752.303
  111.026   253.269   111.026   111.026   277.257   111.026   111.026   253.269   111.026   251.572
  111.026   111.026   111.026   253.269   111.026   111.026   111.026   111.026   111.026  1 97.625
  111.026   111.026   111.026   111.026   172.368   253.269   111.026   111.026   111.026   251.572
  111.026   253.269   111.026   111.026   217.285   111.026   111.026   253.269   111.026   522.345
  111.026   111.026   111.026   253.269   111.026   111.026   111.026   111.026   111.026  1040.840
  111.026   111.026   111.026   111.026   111.026   253.269   111.026   111.026   111.026   606.426
  111.026   253.269   111.026   111.026   217.285   111.026   111.026   253.269   111.026   251.572
  111.026   111.026   111.026   253.269   232.343   111.026   111.026   111.026   111.026   941.712
  111.026   111.026   111.026   111.026   111.026   253.269   111.026   111.026   111.026   251.572
  111.026   253.269   111.026   111.026   217.285   111.026   111.026   253.269   111.026   928.416
```

GLOSSARY OF TERMS

Note: All definitions to be read within the context of this report.

Capital Cost	- Cost of construction, design and supervision, furniture and equipment
Capital Formula	- The formula used by the Ontario Ministry of Colleges and Universities to evaluate a university's entitlement for capital funds. It takes into consideration the university's enrolment, space standards for various categories of students and academic activities, existing space inventory and total project costs per unit of new space (presently $55 per NASF), together with such other factors as building age and utilities requirements. The main component of the formula relates to enrolment. Other components are the age-quality discount, which reduces the existing space inventory for the purposes of the formula ("allocation inventory") for old buildings; cyclical renewal (for definition, see Glossary)
Costs-in-use	- U.K. equivalent of Life Costs
Custodial Services	- All cleaning and janitorial services (see Appendix 5 for broader definition)
Cyclical Renewal	- Major repairs and replacement of building sub-systems, components, furniture and equipment; alterations due to changes in occupancy, use, methodology, technology and code requirements
Housekeeping	- Use "Custodial Services"
Janitorial Services	- Use "Custodial Services"
Life Costs	- Total capital, operating and maintenance costs of a building, building sub-system or component, over an anticipated or selected life in years, expressed in present value dollars
Life Cycle Costs	- U.S. equivalent of Life Costs
Operating and Maintenance Cost	- Cost of building maintenance, custodial services, utilities, renovations, alterations and major repairs
Owning Costs	- Life costs expressed in annual equivalent dollars
Repairs - major	- Part of "Cyclical Renewal"
Repairs - minor	- Part of building maintenance

ACRONYMS

CCF - Committee on Capital Financing (of COU)

COFOUO - Committee of Finance Officers of Universities in Ontario

COU - Council of Ontario Universities

CSP - Capital Support Project

GSF - Gross square feet

HVAC - Heating, ventilation and air conditioning

MCU - Ministry of Colleges and Universities (of Ontario)

NASF - Net assignable square feet

OAPPPA - Ontario Association of Physical Plant and Planning Administrators

O & M Costs - Operating and maintenance costs

INDEX FOR MAINTENANCE AND OPERATING COSTS

In utilizing past actual costs for operating maintenance and utilities for projecting future life costs, it is necessary to eliminate the effect of increases in labour and material costs during the period covered by the data. In other words, the Task Force had to devise an escalation index for maintenance and operating costs. This was done by a method that appears satisfactory, providing the necessary data are available. Further refinement of such an index is recommended as part of the responsibilities of a future Task Force investigating life costs.

At this time, only three components of operating and maintenance costs were considered, namely building maintenance, custodial services and utilities. The relative weights of these three components were established from the 1971/72 operating statements from ten universities, as supplied to the Task Force by M.C.U.

Within each of these categories, further relative weights of labour and material were established, based on actual experience at Windsor and Carleton Universities. A labour cost index was then derived from the hourly rates of pay included in union agreements for the appropriate categories of labour. Material cost indices were derived from the Southam Construction Index for Building Materials and from Statistics Canada Consumer Price Index for Custodial Services and Utilities.

The attempt proved that an index for this purpose could be developed quite easily, but admittedly the methodology needs some further development and possible refinement to accept more detailed breakdowns of data.

The data required and the analysis is shown in the following five tables, which are self-explanatory. The result of the analysis is shown in Table 1, bottom line and it can be seen that annual increases in the composite cost of these elements of operating and maintenance costs increased by between 4.8 and 7.3% during the period studied.

TABLE 1

COMPOSITE INDEX FOR MAINTENANCE AND OPERATING COSTS

Index	Weight (a)	1969	1970	1971	1972	1973
Building Maintenance	25%	100.0	108.6	117.5	124.8	134.9
Custodial Services	33%	100.0	108.3	117.4	123.4	136.6
Utilities	42%	100.0	105.6	110.0	113.9	117.3
Weighted Composite Index	100%	100.0	107.3	114.3	119.7	128.1
Increase over previous year			+ 7.3%	+ 6.6%	+ 4.8%	+6.9%

(a) Based on distribution of costs during 1971/72 at ten Ontario universities

TABLE 2

BUILDING MAINTENANCE INDEX

	Weight	1969	1970	1971	1972	1973
Labour (a)	80%	100.0	109.2	118.8	125.5	132.8
Material (b)	20%	100.0	106.4	112.0	121.7	143.5
Weighted Index	100%	100.0	108.6	117.5	124.8	134.9
Increase over previous year			+ 8.6%	+ 8.1%	+ 6.2%	+8.1%

(a) Based on weighted average from Carleton University (see Table 5)

(b) Based on Southam Construction Index, Material - Ontario Series

TABLE 3

CUSTODIAL SERVICES INDEX

	Weight	1969	1970	1971	1972	1973	1974
Labour (a)	90%	100.0	109.0	119.1	125.4	139.9	151.5
Material (b)	10%	100.0	102.4	102.7	104.8	107.0(1)	
Weighted Index	100%	100.0	108.3	117.4	123.4	136.6	
Increase over previous year			+ 8.3%	+ 8.4%	+ 5.1%	+ 10.7%	

(a) Based on Carleton University (cleaners rate)

(b) Based on Statistics Canada Consumer Price Index - Housing Supplies Component

(1) February 1973

TABLE 4

UTILITIES INDEX

	Weight	1969	1970	1971	1972	1973
Labour (a)	20%	100.0	118.8	128.3	134.7	137.4
Utility cost (b)	80%	100.0	102.3	105.4	108.7	112.3(1)
Weighted Index	100%	100.0	105.6	110.0	113.9	117.3
Increase over previous year			+ 5.6%	+ 4.1%	+ 3.6%	+ 3.0%

(a) 2nd class operating engineer - Windsor

(b) Consumer Price Index - Household Operation Component

(1) February 1973

TABLE 5

BUILDING MAINTENANCE LABOUR PRICE INDEX
(based on Carleton University)

	Weight %	1969	1970	1971	1972	1973	1974
Non-certified Trades Helper (Labourer)	3.0	100.00 (2.39)	109.20 (2.61)	113.81 (2.72)	119.25 (2.85)	129.71 (3.10)	138.08 (3.30)
Locksmith	6.0	100.00 (2.87)	109.06 (3.13)	121.25 (3.48)	129.97 (3.73)	138.68 (3.98)	145.64 (4.18)
Painter	13.0	100.00 (2.94)	109.35 (3.215)	118.37 (3.48)	126.87 (3.73)	135.37 (3.98)	142.18 (4.18)
Carpenter	13.0	100.00 (3.15)	109.05 (3.435)	115.24 (3.63)	119.05 (3.75)	126.98 (4.00)	133.33 (4.20)
A/C & Refrig Mechanic	8.0	100.00 (3.51)	109.26 (3.835)	118.80 (4.17)	126.21 (4.43)	133.33 (4.68)	139.03 (4.88)
Sheet Metal Mechanic	5.0	100.00 (3.66)	109.29 (4.00)	120.22 (4.40)	127.32 (4.66)	134.15 (4.91)	139.62 (5.11)
Electrician	26.0	100.00 (3.86)	109.20 (4.215)	119.69 (4.62)	126.42 (4.88)	132.90 (5.13)	138.08 (5.33)
Plumber / Steamfitter	26.0	100.00 (3.86)	109.20 (4.215)	119.69 (4.62	126.42 (4.88)	132.90 (5.13)	138.08 (5.33)
	100.0						
Weighted Average		100.00	109.20	118.81	125.54	132.80	138.59
Increase over previous year		-	+ 9.2%	+ 8.8%	+ 5.7%	+ 5.8%	+ 4.4%

Figures in brackets are hourly rates

APPENDIX 9

RELATIONSHIP BETWEEN CAPITAL INVESTMENT AND DISCOUNTED ANNUAL SAVINGS

Maximum additional capital investment that should be spent now, to save $1.00 per annum for various periods at selected discount rates

Discount	Period (years)					
Rate	30	40	50	60	75	100
0%	$ 30.0	40.0	50.0	60.0	75.0	100.0
5%	15.4	17.2	18.3	18.9	19.5	19.8
5½%	14.5	16.0	16.9	17.4	17.9	18.1
6%	13.8	15.0	15.8	16.2	16.5	16.6
6½%	13.1	14.1	14.7	15.0	15.2	15.4
7%	12.4	13.3	13.8	14.0	14.2	14.3
7½%	11.8	12.6	13.0	13.2	13.3	13.3
8%	11.3	11.9	12.2	12.4	12.5	12.5
8½%	10.7	11.3	11.6	11.7	11.7	11.8
9%	10.3	10.8	11.0	11.0	11.1	11.1
9½%	9.8	10.2	10.4	10.5	10.5	10.5
10%	9.4	9.8	9.9	10.0	10.0	10.0

Source: Interest and annuity tables, present value of $1 per annum at compound interest